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PALEONTOLOGY.—*A further contribution to the Dragon Paleocene fauna of central Utah.*[1] C. LEWIS GAZIN, U. S. National Museum.

Additional material of Paleocene Mammalia from the upper portion of the North Horn formation in central Utah was obtained by the 1938 Smithsonian Institution expedition in search of fossil vertebrates. The greater part of the collection was made from deposits of limited exposure in Dragon Canyon, in the western half of section 8, T. 19 S., R. 6 E. A few specimens were collected at a locality on the south end of Wagon Road Ridge to the west of Dragon Canyon and at a much higher elevation. The North Horn formation, together with the capping Flagstaff limestone and the older rocks, is much faulted in this region, and the Paleocene deposits in Dragon Canyon are a part of a depressed block separated by one or more north-south striking faults from the higher standing rocks of Paleocene age in the mountainous masses to the east and to the west.

The new materials collected during the 1938 season show the Dragon fauna to be more varied than had been recognized from the less extensive, though important, collection made in 1937. The specimens so far found are more fragmentary than the average of those coming from the better known deposits in the San Juan Basin and Crazy Mountain fields. In addition to crocodile and champsosaurid remains, the collection now includes material representing about 19 mammalian forms, of these 9 are recognized as new species, and three new genera are proposed. The following is a list of the Mammalia:

MULTITUBERCULATA:
Catopsalis utahensis, n. sp.
Ptilodus sp.

INSECTIVORA:
Aphronorus simpsoni Gazin
Insectivore? gen. and sp. undet.

PRIMATES?:
Primate? gen. and sp. undet.

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TAENIODONTA:
Conoryctella dragonensis, n. gen. and sp.
CARNIVORA:
Protogonodon? spiekeri Gazin
Oxyclaenus? sp.
Oxyclaenid near *Tricentes*
Didymictis? sp.
TALIGRADA:
Periptychus gilmorei Gazin
Anisonchus dracus, n. sp.
Anisonchus onostus, n. sp.
Haploconus inopinatus, n. sp.
CONDYLARTHRA:
Dracoclaenus griphus, n. gen. and sp.
Ellipsodon shepherdi, n. sp.
Ellipsodon? sternbergi, n. sp.
Ellipsodon? sp.
Jepsenia mantiensis, n. gen. and sp.

Most of the above forms are rather sparsely represented, the Condylarthra including the more common forms. Material of *Ellipsodon* and of the new group *Dracoclaenus* is relatively most abundant, although that of periptychids, especially *Periptychus gilmorei*, is not uncommon.

The intermediate character of the fauna between that of the Puerco and that of the Torrejon, previously noted in the relationships of *Periptychus gilmorei* and of *Protogonodon? spiekeri*, is further indicated in the relationships of *Conoryctella dragonensis* and of *Anisonchus dracus*. These have related types in both the Puerco and Torrejon faunas. The remaining forms in the Dragon fauna either do not have comparable types in one or the other of the two San Juan horizons or the material is too fragmentary to permit more than the most casual comparisons. Five of the forms listed—*Catopsalis*, *Ptilodus*, *Aphronorus*, *Didymictis*, and *Haploconus*—suggest in name a closer approach to the Torrejon stage. Such may be the case; however, since the ancestry of these forms in the Puerco horizon is not known, the relative position in time which they suggest is doubtful. The problems of each of the forms will be discussed under their respective headings.

I wish to acknowledge the courtesy extended by Dr. Walter Granger in permitting comparisons with Paleocene materials in the American Museum of Natural History and by Dr. Glenn L. Jepsen, of Princeton University, in permitting me to examine Paleocene materials from the Big Horn Basin. The drawings illustrating certain of the Dragon specimens were made by Sydney Prentice.

SYSTEMATIC DESCRIPTION OF THE MATERIAL

MULTITUBERCULATA

Catopsalis utahensis, n. sp.

Type.—Left M_1, U.S.N.M. no. 15757.

Horizon and locality.—Dragon Paleocene, Dragon Canyon, Emery County, Utah.

Specific characters.—Cusp formula: M_1 6:4. Length of M_1 approximately 12 mm. Width 6.5 mm.

Description.—A single first lower molar is recognized as representing a taeniolabid multituberculate. The tooth exhibits the simple type of pattern seen in *Catopsalis* from the Torrejon rather than the more specialized dental structure of the Puerco *Taeniolabis*. It differs from species of *Catopsalis* known from the Torrejon of the San Juan Basin in the cusp formula of M_1. In *Catopsalis foliatus* it is 5:4, and in *C. fissidens* the formula is 6:5 or better. Moreover, the tooth appears relatively wider than in either of the Torrejon species. *C. calgariensis* Russell from the Paskapoo was described from a second lower molar; hence no satisfactory comparison is possible.

The relative position in time of the genera *Taeniolabis* and *Catopsalis*, as pointed out by Granger and Simpson, appears paradoxical; consequently one should expect to find, eventually, other taeniolabids representing ancestral stages of *Catopsalis* in beds earlier than Torrejon. The single tooth of *C. utahensis* does not seem to present any significant evidence as to ancestral stages in the development of the genus *Catopsalis*, but appears only to extend its known geologic range to a somewhat earlier part of the Paleocene.

Ptilodus sp.

A lower jaw fragment, U.S.N.M. no. 15730, including the basal portion of the incisor and the anterior part of P_4 is considered to represent *Ptilodus*, a conclusion in which Dr. G. L. Jepsen of Princeton University concurs. The material is too incomplete to permit specific comparisons, but the specimen indicates an animal not greatly different in size from *Ptilodus mediaevus* of the Torrejon.

Material of *Ptilodus* is not known elsewhere in beds earlier than Torrejon; hence a consideration of the development of *Ptilodus* during earlier Paleocene time remains speculative and based on what is known of related types in the Cretaceous. Here again, *vide* Granger and Simpson, the position of *Ptilodus* relative to the more specialized *Eucosmodon*, known from the Puerco as well as the Torrejon, seems capricious but indicates a diversity of phyletic lines.

INSECTIVORA

Aphronorus simpsoni Gazin

Only a few fragmentary specimens of this form were obtained by the 1938 expedition. These add little or nothing to the diagnosis made in the original description. Except for a noticeably worn upper molar, tentatively referred to this form, the material consists of lower teeth or jaw portions.

Insectivore? gen. and sp. undet.

A jaw fragment with M_3 and perhaps other isolated teeth may represent one of more Insectivora other than *Aphronorus*.

PRIMATES?

Primate? gen. and sp. undet.

In a fragment of a jaw, U.S.N.M. no. 15719, a molar tooth, M_1 or M_2, in which the crown of the trigonid is broken away, exhibits a talonid portion so closely resembling that in the Fort Union primates as to indicate strongly affinities with that group. The heel shows a wide basin with a prominent hypoconid and somewhat less important entoconid, no accessory cuspules and the posterior wall of the tooth appears only slightly convex between the two cusps. The specimen is close to *Paromomys maturus* Gidley in size but probably does not represent the same genus. The talonid portion has a width of 2 mm.

If the affinities of this very fragmentary specimen are properly understood, it represents the earliest primate known.

TAENIODONTA

Conoryctella, n. gen.

Type.—Conoryctella dragonensis, n. sp.

Generic characters.—Near *Conoryctes* but P^4 not molariform, tritocone (metacone) not comparable to protocone and deuterocone in development, and no indication of a metaconule. Teeth less hypsodont, cusps lower, with heavy cingulum around outer cusps of upper molars. Mesostyle less prominent. Paraconid in M_1? unreduced in a referred specimen.

Conorcytella dragonensis, n. sp. Fig. 1

Type.—Portion of left maxilla with P^4 to M^2, U.S.N.M. no. 15704.

Horizon and locality.—Dragon Paleocene, Dragon Canyon, Emery County, Utah.

Specific characters.—Smaller than *Conoryctes comma* but much larger than *Onychodectes tisonensis.*

Description.—The upper teeth, made the type of *Conoryctella dragonensis,* are only a little smaller than in *Conoryctes comma* but distinctly larger than in *Onychodectes tisonensis.* The Dragon form is about intermediate between these two species in degree of hypsodonty. P^4 is not so nearly molariform as in *C. comma* and has the lingual portion more compressed anteroposteriorly. The protocone and deuterocone are prominent conical cusps, and the tritocone, though damaged, is seen to be but weakly developed as compared to the two other cusps. The lingual portion of this tooth does not appear crescentic; nevertheless, a low crest or cingulum extends along the posterior portion between the deuterocone and tritocone.

The paracone and metacone in the first two molars, as far as preserved, are seen to be conical and low and are separated from the outer margin of the teeth by a heavy cingulum. The mesostyle, though present, is not so strongly developed as in *C. comma.* It is absent in *O. tisonensis.* The anteroexternal and posteroexternal angles of the teeth are more rounded than in *O. tisonensis* and do not exhibit styles at these points such as in the Puerco form.

The anteroposterior diameters of the upper teeth, P^4 to M^2, are approximately 7.5, 8.2, and 7.4 mm, respectively. Any transverse measurements would be highly arbitrary.

A lower jaw fragment, U.S.N.M. no. 15722, with a molar tooth, apparently M_1, may represent *Conoryctella dragonensis,* although it is from an individual somewhat smaller than the type. The tooth is about intermediate between *O. tisonensis* and *C. comma* in hypsodonty but apparently a little

nearer *O. tisonensis* in size. The trigonid of the tooth possesses a moderately developed paraconid situated much as in M_1 of *O. tisonensis*. The heel or talonid, though partially obscured by matrix is relatively broad, appears to be deeply basined and to have a somewhat cuspidate crest, approaching the condition seen in *C. comma*.

The Dragon lower tooth does not exhibit the basal accessory cuspule anteroexternal to the hypocone seen in *Onychodectes rarus*.

CARNIVORA

Protogonodon? spiekeri Gazin

Only a third upper molar and a portion of a lower molar of *Protogonodon? spiekeri* were added to the collection by the 1938 expedition. The characters of these teeth were known from material collected in 1937; hence nothing new can be added to the diagnosis of this form.

Oxyclaenus? sp.

A lower jaw fragment, U.S.N.M. no. 15776, with M_2 and part of M_1, resembles closely, in the characters of M_2, a lower tooth belonging to the type *Oxyclaenus simplex* and material referred to *O. cuspidatus*. It differs from these only in having the crest connecting the paraconid and protoconid extending slightly less anteroexternally, in the absence of a very small cuspule probably unimportant, anterior to the entoconid, which tends to close the talonid basin internally in the Puerco material, and in somewhat less development of the hypoconulid. The second molar has about the proportions of the lower tooth belonging with the type of *O. simplex* and exhibits a well-marked external cingulum.

Another lower molar, no. 15784, apparently an M_1, possibly of the same form, is distinguished by having the paraconid somewhat more median in position and lacking the external cingulum.

Oxyclaenid, near Tricentes

An isolated upper molar, U.S.N.M. no. 15783, apparently M_1, is recognized as coming from an oxyclaenid type of creodont belonging to or near *Tricentes*. The tooth is about one-fifth smaller than in *Tricentes subtrigonus* from the Torrejon. The cusps have about the same conical appearance, and the hypocone occupies a position equivalent to that in *Tricentes;* also, the cingulum is not continuous across the buccal surface of the paracone, a condition characteristic of M^1 in *Tricentes*. However, the enamel appears less rugose than in *T. subtrigonus* and the cingulum lingually is not continuous across the protocone.

Didymictis? sp.

A fourth lower premolar, U.S.N.M. no 15763, apparently represents the genus *Didymictis*. The tooth is only slightly smaller than in *Didymictis haydenianus* from the Torrejon but does not have the first cuspule posterior to the large cusp so distinctly set off from this primary cusp. The cuspules of the talonid are more nearly in the median line of the tooth than was observed in *D. haydenianus*. The tooth is distinctly larger than in *D. microlestes* from the Crazy Mountain locality in the Fort Union of Montana.

An isolated fourth upper premolar may possibly belong to *Didymictis* but is too small to belong to the form represented by the lower tooth. Moreover, the deuterocone portion does not extend forward so markedly as in the Torrejon material of *Didymictis*, a condition suggestive of *Ictidopappus*, but the

posterior cusp, though prominent, is not developed into so nearly a shearing blade as in either *Didymictis* or *Ictidopappus*.

TALIGRADA

Periptychus gilmorei Gazin

Several additional specimens of this large peritychid were obtained in 1938, the most significant being portions of the right and left rami of a lower jaw, U.S.N.M. no 15689, exhibiting P_4 to M_3. This material further warrants the conclusions drawn from the upper dentitions figured in an earlier paper. The lower teeth are also nearly intermediate in most respects between *Carsioptychus coarctatus* from the Puerco and *Periptychus carinidens* of the Torrejon. The protocone of P_4 is not directed posteriorly so markedly as in *C. coarctatus*, and a small anterointernal cusp is present, this being prominent in *P. carinidens* but usually absent in *C. coarctatus*. On the posterointernal portion of the tooth there is a small cusp; the talonid, however, is not developed so much as in *P. carinidens*. The extent to which a metaconid has become distinct from the protoconid can not be exactly determined, owing to wear, but it is clearly not separated to the extent seen in *P. carinidens*.

The lower molars are wider than in the *Carsioptychus* material at hand but not so wide as is common in Torrejon material of *Periptychus*. These teeth show a slight cingulum around the external side, which was not observed in material of the other forms. The small seventh cusp located about in the center of the crown of the lower molars of *Periptychus carinidens* is not present in the first two molars of *P. gilmorei* but is weakly developed in M_3. This cusp is not known in *Carsioptychus*.

TABLE 1.—MEASUREMENTS (IN MILLIMETERS) OF LOWER TEETH OF *Periptychus gilmorei*

	P_4	M_1	M_2	M_3
Anteroposterior diameter	11	10.3	10	11.5
Transverse diameter	9.6	8.7	9.7	9

Anisonchus dracus, n. sp. Fig. 2

Type.—Maxillary fragment with P^4 to M^3, U.S.N.M. no 15745.

Horizon and locality.—Dragon Paleocene, Dragon Canyon, Emery County, Utah.

Specific characters.—Intermediate in position of cusps and in relative proportions of the upper cheek teeth between *Anisonchus gillianus* and *A. sectorius*.

Description.—The maxillary fragment, no. 15745, with cheek teeth P^4 to M^3 inclusive, clearly belongs to the genus *Anisonchus* and is intermediate in the observed characters between *A. gillianus* and *A. sectorius* of the Puerco and Torrejon, respectively. As has been noted in the comparisons of *Periptychus gilmorei* with comparable forms in the Puerco and Torrejon, the upper cheek teeth in the Dragon *Anisonchus* are of an intermediate character in the relation of the length to the width of the crowns.

The Dragon form approaches *A. sectorius* in size but retains relatively wider teeth transversely, and longitudinally a little shorter, and the cusp pattern is not so restricted transversely. The upper teeth appear also to have a longer, more gradually sloping lingual wall, with a somewhat more lingually placed hypocone column. The lingual portion of P^4 seems more con-

stricted anteroposteriorly and apparently has a less conspicuously developed lingual crescent.

A. gillianus has teeth relatively wide transversely, the length of the tooth

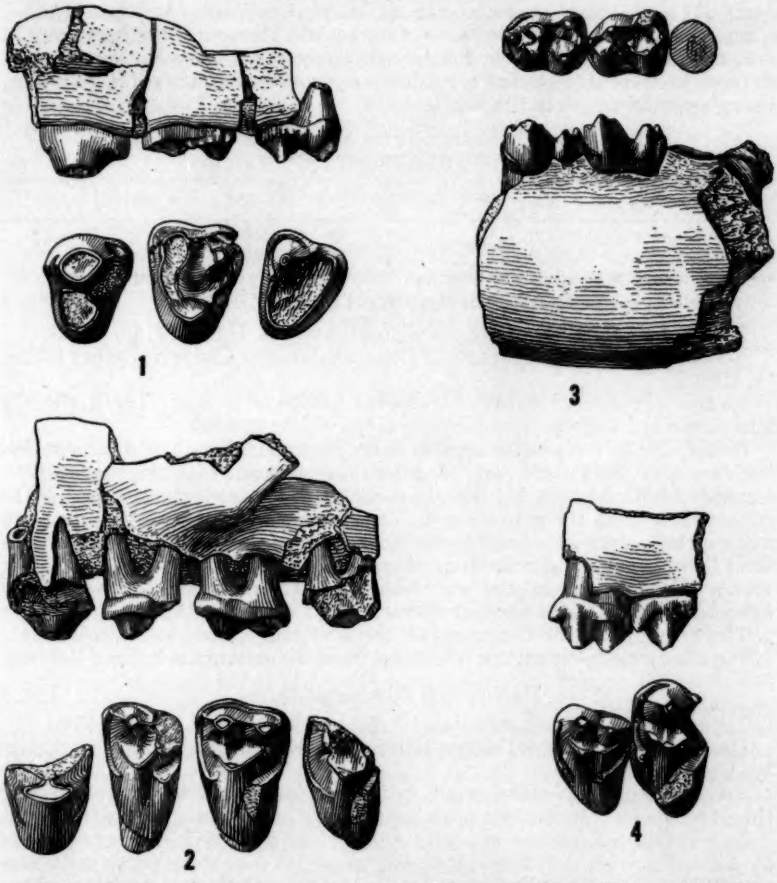


Fig. 1.—*Conoryctella dragonensis*, n. gen. and sp. Left P^4 to M^2, type, U.S.N.M. no. 15704. Lateral and occlusal views. ×1.8. Fig. 2.—*Anisonchus dracus*, n. sp. Left P^4 to M^2, type, U.S.N.M. no. 15745. Lateral and occlusal views. ×3. Fig. 3.—*Anisonchus onostus*, n. sp. Left M_1 and M_2, type, U.S.N.M. no. 15788. Occlusal and lateral views. ×3. Fig. 4.—*Haploconus inopinatus*, n. sp. Left M^1 and M^2, type, U.S.N.M. no. 15760. Lateral and occlusal views. ×3.

row shorter, and the hypocone is placed more lingually with respect to the metacone, and to a certain extent with respect to the protocone, than in *A. sectorius*.

Two isolated jaw fragments, U.S.N.M. nos. 15715 and 15787, each with

a single molar, presumably both M_2, are nearly equal in size to *Anisonchus sectorius* and show no significant differences from either *A. sectorius* or *A. gillianus*. However, the crest connecting the hypoconid to the trigonid appears distinctly lower than that connecting the entoconid to the metaconid. This condition was noted in an M_1 of *A. gillianus* but not in other specimens of either this species or *A. sectorius*. Moreover, the hypoconulid does not project backward in the molars referred to *Anisonchus dracus* quite so far as in M_2 of *A. sectorius*, a condition approximated in M_2 of *A. gillianus*, though possibly of doubtful significance.

TABLE 2.—MEASUREMENTS (IN MILLIMETERS) OF UPPER TEETH OF *Anisonchus dracus*

	P^4	M^1	M^2	M^3
Anteroposterior diameter	5?	4.4?	4.8	4?
Greatest transverse diameter		6.6?	7.8	

Anisonchus onostus, n. sp. Fig. 3

Type.—Left ramus of mandible with M_1 and M_2, U.S.N.M. no 15788.

Horizon and locality.—Dragon Paleocene, Dragon Canyon, Emery County, Utah.

Specific characters.—Near *Anisonchus gillianus* in size. Teeth slightly lower crowned and cusps of talonids more widely spaced.

Description.—*Anisonchus onostus* is decidedly smaller than *A. dracus*, being very near the Puerco form *A. gillianus* in size but with the cusps on the talonid of both M_1 and M_2 slightly more widely spaced, though having the cut characterizing the anisonchines. This spacing of the cusps gives the teeth a somewhat wider appearance, whereas actually they are a trifle narrower than those in several specimens of *A. gillianus* with which comparisons were made. The teeth also appear somewhat lower crowned than those of *A. gillianus* exhibiting about the same wear.

The anteroposterior diameters of the first and second lower molars are 4.3 and 4.1 mm, respectively. The transverse diameters are 2.9 and 3.2 mm.

Haploconus inopinatus, n. sp. Fig. 4

Type.—Portion of left maxilla with M^1 and M^2, U.S.N.M. no. 15760.

Horizon and locality.—Dragon Paleocene, Dragon Canyon, Emery County, Utah.

Specific characters.—Size small. Second molars much wider transversely than first molars. Protostyle prominent. Slight development of metaconule.

Description.—A second genus of anisonchine periptychids is represented by a maxillary portion with M^1 and most of M^2. The form apparently represents *Haploconus* as indicated by the prominent lingual position of the hypocone. It appears in size to be close to the Torrejon material referred to *Haploconus angustus* but with the teeth relatively wider transversely and with M^2 relatively much wider than M^1. A difference in width between M^1 and M^2 was noted in certain specimens of *Haploconus* referred to *H. angustus* but apparently the difference is not so marked as in *Haploconus inopinatus*.

The two upper molars show a slight development of a metaconule, but most noticeable is the distinct protostyle that characterizes teeth in *Haploconus corniculatus*. *H. inopinatus* is much smaller than the type of *H. corniculatus*, and in the latter the upper molars appear to be relatively as well as actually much longer anteroposteriorly than in the Dragon form.

The anteroposterior diameter of the first upper molar is 4.3 mm. The greatest transverse diameters of the first and second upper molars are 6.1 and 7.1 mm, respectively.

A lower jaw portion, U.S.N.M. no. 15744, with M_1 and M_2 poorly preserved, and partially obscured by ironlike matrix, appears to represent *Haploconus* in the absence of a paraconid and in the bladelike form of the protoconid on M_1. It corresponds closely in size to the type of *Haploconus angustus*, but with M_1 narrower, particularly the anterior portion, and M_2 wider than in the Torrejon form. This suggests that the premolars in the Dragon form may not have been so robust as in the Torrejon stage.

CONDYLARTHRA

Dracoclaenus, n. gen.

Type.—*Dracoclaenus griphus*, n. sp.

Generic characters.—Near *Protoselene*, but P^4 much more inflated and with tritocone almost indistinct. Anteroexternal and posteroexternal styles on P^4 prominent. M^1 appreciably smaller than M^2. External cingulum on upper molars strong and mesostyle present though distinct from crest connecting paracone and metacone, paraconid on lower molars more lingual in position than in *Protoselene*, and in M_2 this cusp is less reduced and not placed so low. Talonid on lower molars somewhat shallower and narrower between hypoconid and entoconid.

Dracoclaenus griphus, n. sp. Figs. 5–7

Type.—Fragment of right maxilla with M^1 and M^2, U.S.N.M. no. 15789.

Horizon and locality.—Dragon Paleocene, Dragon Canyon, Emery County, Utah.

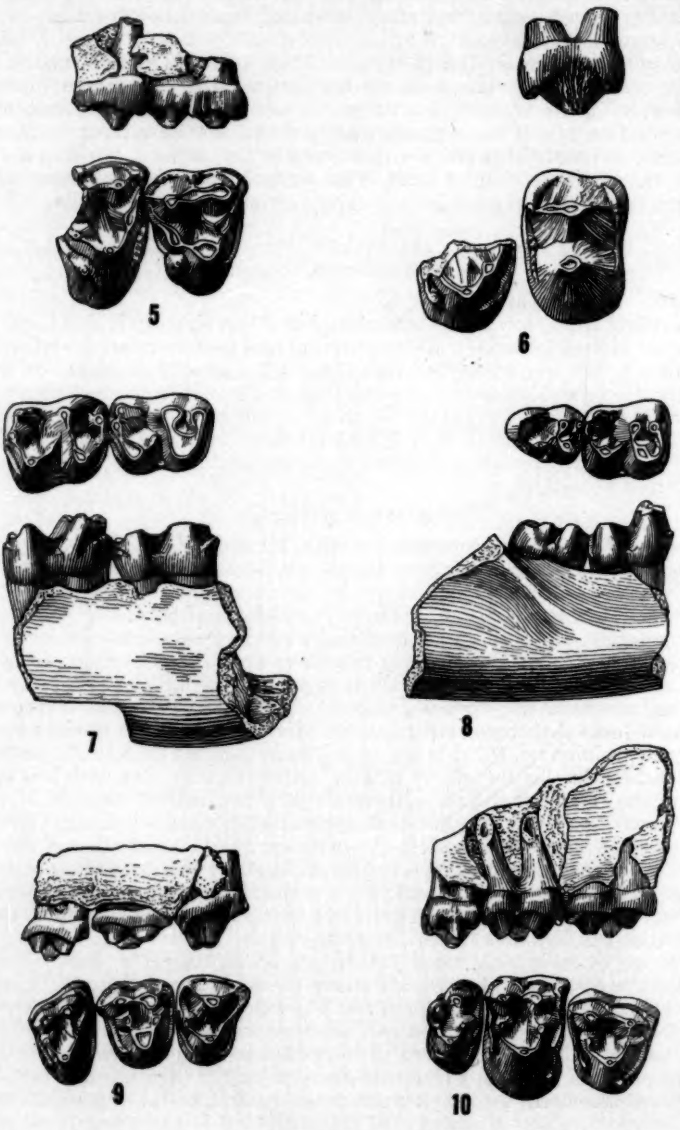
Specific characters.—Close in size to *Protoselene opisthacus*.

Description.—The material here considered to represent the new form *Dracoclaenus griphus* most closely resembles that of the Torrejon form *Protoselene opisthacus* but differs from it in several respects. A relatively large number of specimens, though fragmentary, are considered as representing this new form and three are figured and form the basis for the description.

P^4 in specimen no. 15705 is larger and more inflated than in *P. opisthacus*, approaching in this respect P^4 in *Mioclaenus turgidus*, but with less reduction of the cingulum and no metaconule such as usually present in *M. turgidus*. The tritocone of P^4 in *Dracoclaenus griphus* is almost indistinct from the protocone, whereas this tooth in *P. opisthacus* exhibits a division of the main outer cusp into a prominent protocone and a lesser tritocone placed close together. The anteroexternal and posteroexternal styles are more prominent on P^4 of the Dragon form, and a slightly better developed cingulum, though discontinuous, is indicated on the outer surface.

The upper molars, M^1 and M^2, in no. 15789 resemble closely those in *Protoselene opisthacus*, but the difference in size between these teeth is more noticeable than in the Torrejon form. The external cingulum is more prominent and more markedly crescentic about each the paracone and metacone. The mesostyle is about as well developed as in *P. opisthacus* but distinctly separated from the crest which extends between the paracone and metacone. In *P. opisthacus* the mesostyle extends outward as a spur or projection from this crest.

Another upper dentition, including P^4 to M^2, no. 15703, resembles the type in most characters of the molars but has a weaker hypocone on both molars and a very weak metaconule on M^2. The anteroexternal angle of M^2



Figs. 5–10—(See opposite page for description.)

extends forward somewhat more, suggestive of the oxyclaenids, but has the mesostyle, particularly in M^1, as in no. 15789. The external cingulum is not so crescentic around the outer cusps, the outer wall being more nearly straight. P^4 is similar but a little smaller than in nos. 15705 and 15780. This specimen, no. 15703, may represent a distinct species of *Dracoclaenus* or may possibly be of an oxyclaenid, close in size to *Oxyclaenus simplex*, however, P^4 and M^1 more closely resemble the *Dracoclaenus* material.

The lower jaw portion, no. 15773, considered by comparison to represent *Dracoclaenus griphus*, also resembles material of *Protoselene*. It corresponds closely in size to *P. opisthacus*, but has the paraconid on M_1 and M_2 more internal in position, and in M_2 it is not placed so low and is less reduced than in *P. opisthacus*. The talonid basin is apparently not so deep and is narrower between the hypoconid and entoconid. A slight accessory cusp is present on the anterior crest of the entoconid nearly as prominent as in *P. opisthacus*.

An M_3, no. 15752, in the collection, possibly belonging to this form, does not so closely resemble *P. opisthacus*. The paraconid, though low, is placed more internal than is usual in the Torrejon form. Moreover, the entoconid is not so simple as usual in *P. opisthacus*, exhibiting three small cusps in this position, and the hypoconulid is more distinctly separated from the hypoconid.

TABLE 3.—MEASUREMENTS (IN MILLIMETERS) OF UPPER TEETH, NO. 15789, AND LOWER TEETH, NO. 15773, OF *Dracoclaenus griphus*

	M^1	M^2	M_1	M_2
Anteroposterior diameter	5.4		5.3	5.3
Transverse diameter	6.4	7.5	4	4.4

Ellipsodon shepherdi, n. sp. Figs. 8–9

Type.—Right ramus of mandible with M_2 and M_3, U.S.N.M. no. 15721.

Horizon and locality.—Dragon Paleocene, Dragon Canyon, Emery County, Utah.

Specific characters.—Teeth somewhat smaller than in *Ellipsodon lemuroides* and a little larger than in *E. acolytus*. P^4 with a metaconule, distinct from cingulum. Paraconid distinct and lingually placed in M_2 and M_3. M^3 and M_3 reduced in size.

Description.—Ellipsodon shepherdi, as indicated by the type lower jaw, is slightly smaller than *E. lemuroides*, and the molars M_2 and M_3 are relatively narrower. M_3 is reduced to about the same extent as in *E. lemuroides*, more reduced than in the smaller forms, *E. aequidens*, *E. acolytus*, and *E. aquilonius*, but less reduced than in the Puerco species, *E. priscus*, and possibly somewhat less reduced than in the genotype, *E. inaequidens*. The paraconid of the last two lower molars is more distinct in the Dragon form than in any of the previously known species of *Ellipsodon*, much better developed

Fig. 5.—*Dracoclaenus griphus*, n. gen. and sp. Right M^1 and M^2, type, U.S.N.M. no. 15789. Lateral and occlusal views. ×3. Fig. 6.—*Dracoclaenus griphus*, n. gen. and sp. P^4 and M^1 (part), U.S.N.M. no. 15705. Lateral and occlusal views. ×3. Fig. 7.—*Dracoclaenus griphus*, n. gen. and sp. Right M_1 and M_2, U.S.N.M. no. 15773. Occlusal and lateral views. ×3. Fig. 8.—*Ellipsodon shepherdi*, n. sp. Right M_2 and M_3, type, U.S.N.M. no. 15721. Occlusal and lateral views. ×3. Fig. 9.—*Ellipsodon shepherdi*, n. sp. Right P^4 to M^2, U.S.N.M. no. 15790. Lateral and occlusal views. ×3. Fig. 10.—*Jepsenia mantiensis*, n. gen. and sp. Right M^1 to M^2, type, U.S.N.M. no. 15747. Lateral and occlusal views. ×3.

and more lingually placed than in *E. aequidens*, but only slightly more prominent than in *E. aquilonius*. The talonids of M_2 and M_3 are more distinctly basined than in Torrejon material referred to *E. inaequidens*, but less distinctly basined than in *E. aquilonius* from Montana, also, the talonid on M_3 is better developed than in the Puerco form, *E. priscus*. Moreover, the talonid of M_2 in *E. shepherdi* does not exhibit so prominent a hypoconulid as in *E. aequidens*, but shows a more distinct entoconid than in *E. inaequidens*.

The upper teeth, P^4 to M^2, in the maxilla, U.S.N.M. no. 15790, referred to *Ellipsodon shepherdi* are relatively smaller than in the type lower jaw and approach somewhat closer to *E. acolytus* than to *E. lemuroides* in size, however, this difference within the Dragon material may not be greater than can be accounted for by individual variation.

P^4 shows a cusp in the position that would be occupied by the metaconule in the molars. This is absent in the somewhat smaller P^4 of the Puerco form, *E. priscus*, but was observed in certain specimens of the later material. P^4 is noticeably larger than in *E. aequidens*, and M^1 and M^2 are relatively longer.

An M^3 if properly referred, indicates this tooth to be more reduced than in *E. lemuroides*, and much more reduced than in *E. acolytus*, *E. aequidens*, and *E. aquilonius*.

The upper teeth do not closely resemble those in the genotype, *E. inaequidens*. The upper teeth in the latter exhibit smooth crests running to the protocone and weak or undeveloped cingula.

TABLE 4.—MEASUREMENTS (IN MILLIMETERS) OF UPPER TEETH, NO. 15790, AND LOWER TEETH, NO. 15721, OF *Ellipsodon shepherdi*

	P^4	M^1	M^2	M_2	M_3
Anteroposterior diameter	3.7	3.9	3.6	4.4	3.8
Transverse diameter	4.5	4.9	5.8*	4	2.9

* Greatest transverse diameter.

Ellipsodon? sternbergi, n. sp.

Type.—Fragment of right ramus of mandible with M_3 and part of M_2, U.S.N.M. no. 15755.

Horizon and locality.—Dragon Paleocene, Dragon Canyon, Emery County, Utah.

Specific characters.—Considerably more robust than *Ellipsodon shepherdi* or *E. lemuroides* but much smaller than *Mioclaenus turgidus*. Molars simple and relatively broad. M_3 oval in shape and reduced in size.

Description.—A species nearly intermediate in size between *Ellipsodon lemuroides* and *Mioclaenus turgidus* is represented by a few fragmentary specimens, including a jaw portion with M_3 and a part of M_2, which is made the type of *Ellipsodon sternbergi*. M_2 is much larger and broader than in other species of *Ellipsodon;* however, it apparently shows no crenulation of the crest around the posterointernal margin of the talonid as seen in many of, though not all, the lower dentitions of *M. turgidus*. The paraconid is only weakly developed on a referred M_2, which has this portion of the tooth preserved. M_3 is only a little larger than in *Ellipsodon shepherdi* and somewhat more rounded, being nearly oval in shape. The paraconid is lacking on M_3 with only a low crest extending across the front of the tooth, connecting the protoconid and metaconid. Though reduced, the paraconid is present in all specimens of *Mioclaenus turgidus* in which M_3 was observed.

There is no certainty that this form represents the genus *Ellipsodon*, particularly since the premolars are not known. It is possible that a small species of *Mioclaenus* is represented.

The transverse diameter of the second lower molar is about 5 mm. The anteroposterior and transverse diameters of the third lower molar are 4.4 and 3.3 mm, respectively.

Ellipsodon? sp.

A lower jaw, U.S.N.M. no. 15781, is unusual in that the two teeth preserved, M_1 and M_2, have rather blunt cusps, a flattened talonid, and a relatively undepressed area between the three cusps of the moderately elevated trigonid. It resembles somewhat specimens from the Torrejon that have been referred to *Ellipsodon inaequidens* but with the paraconid more distinctly set off, although this cusp is subdued as are the other cusps of the teeth. This may represent an unusual condition in *E. shepherdi* but probably represents a distinct form whose affinities are uncertain.

Jepsenia, n. gen.

Type.—*Jepsenia mantiensis*, n. sp.

Generic characters.—Near *Litaletes*, but lingual portion of M^2 more expanded anteroposteriorly and hypocone weaker. Cusps of molars, particularly protoconule and metaconule, more nearly conical. Paraconule and metaconule better developed. Parastyle and mesostyle developed, more noticeably on M^2, although cingulum at anteroposterior angle of tooth not so extended. M^3 relatively smaller with less development of metacone and cingulum.

Jepsenia mantiensis, n. sp. Fig. 10

Type.—Portion of right maxilla with M^1 to M^3, U.S.N.M. no. 15747.

Horizon and locality.—Dragon Paleocene, Dragon Canyon, Emery County, Utah.

Specific characters.—*Jepsenia mantiensis* is slightly larger than *Litaletes disjunctus*.

Description.—*Jepsenia mantiensis* makes the closest approach to *Litaletes disjunctus* of the various hypsodont condylarths with which comparisons have been made. The upper molar series designated as the type is only slightly more robust than in the Montana form. M^1 has about the relative proportions of that in *L. disjunctus* and shows a distinct hypocone about as in that form. However, the lingual portion of M^2 is more expanded anteroposteriorly and the hypocone in this tooth is weaker and represented only by the abrupt termination lingually of the posterior cingulum. Also, the midportion of the posterior cingulum on both M^1 and M^2 is not deflected upward toward the root portion of the teeth so much as in *L. disjunctus*. The cusps in the upper molars have a more nearly conical appearance, especially the protoconule and metaconule. Moreover, the protoconule and metaconule are distinctly better developed. A parastyle and mesostyle are present, more noticeable in M^2, although the cingulum is not so extended at the anteroexternal portion of the molars. M^3 is relatively smaller than in *L. disjunctus* and the metacone, though distinct, is not so well developed, and the cingulum is less prominent and is discontinuous around the lingual and buccal surfaces of the tooth.

An M^2 with material numbered 15544 shows more acute anteroexternal and posteroexternal styles, no mesostyle, a lower protocone than in *L. disjunctus*, protoconule and metaconule relatively weak as in *L. disjunctus*, but

the hypocone is much more lingual in position and is nearly matched by a protostyle on the anterolingual portion of the tooth, with the cingulum almost but not quite continuous around the inner margin of the protocone. M^1 in this material, though lacking a mesostyle, corresponds closely to that in the type of *Jepsenia mantiensis*. It is possible that the two molars, which were found close together, belong to the same individual and may represent a form distinct from the foregoing.

TABLE 5.—MEASUREMENTS (IN MILLIMETERS) OF UPPER TEETH OF *Jepsenia mantiensis*

	M^1	M^2	M^3
Anteroposterior diameter	4.5	4.4	3
Transverse diameter	5.4	6.4	4.6*

* Greatest transverse diameter.

Several isolated jaw fragments with single molars, one with M_2 and part of M_1, another with a well-worn M_2 and M_3, are presumed to represent *Jepsenia mantiensis*. The lower teeth in general show a distinct paraconid in a lingual position and a basined talonid with a strong hypoconid, a moderate entoconid, and a weak hypoconulid, which is the dorsal termination of a slight posterior cingulum rising from the posteroexternal portion of the tooth. The trigonid portion is not greatly different from that in *L. disjunctus*, although the entoconid on the heel is generally better developed and the small cuspule anterior to the entoconid is more distinct, however, in certain of the referred teeth there is little evidence of this accessory cusp.

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ORNITHOLOGY.—*Notes on some Asiatic owls of the genus* Otus, *with description of a new form.*[1] H. FRIEDMANN and H. G. DEIGNAN, U. S. National Museum.

I

In the collections of Siamese birds in the U. S. National Museum are two specimens of *Otus* that are widely different from any other Asiatic form of the genus but are so closely and obviously related to the African *Otus senegalensis* that, in spite of the enormous geographical interval involved, we have no hesitancy in placing them in that species. In view of the difficulties inherent in such variable and poorly known birds as the Asiatic forms of *Otus*, we have borrowed extensively from the following institutions and private collectors, to whom our thanks are hereby expressed: The American Museum of Natural History, the Academy of Natural Sciences of Philadelphia, the Museum of Comparative Zoology, the Field Museum of Natural History, the Raffles Museum, and W. Koelz.

Otus senegalensis distans, subsp. nov.

Subspecific characters.—Very similar to (almost indistinguishable from) *Otus senegalensis hendersoni* of Angola but slightly washed with buffy on the upperparts, this wash especially noticeable on the pale bars of the outer rectrices and the primaries, and with the feathers of the lower sides and flanks less vermiculated, more whitish than in *O. s. hendersoni*.

Type.—U.S.N.M. no. 349931, adult female, collected at Sala Me Tha, Chiengmai Province, North Siam, February 20, 1936, by H. G. Deignan.

Description of type.—General color of upperparts dark brownish gray, *conspicuously mottled with black and white*. Feathers of crown largely black, with brownish-gray border, sometimes with a whitish spot. Feathers of nape gray or whitish, with an irregular black streak along apical third of shaft and narrow broken black bars, concealed portion washed with pale ferruginous. An ill-defined pale ferruginous collar across upper back, caused by color of concealed portion of feathers, which are otherwise white with a broad black streak along apical third of shaft and with black irregular crossbars. Feathers of back with a broad black shaft-streak, otherwise vermiculated with black and grayish white, sometimes washed with pale ferruginous. Rectrices light gray-brown with blackish-brown vermiculations and shaft-streaks. Outer webs of primaries broadly barred pale gray and brownish black; inner webs blackish brown with broad dull rufous bars, which become white toward edge approaching base of feather. Outer webs of secondaries broadly barred dull rufous and blackish brown; inner webs blackish brown with large white patches, not reaching shaft and inwardly tinged with pale ferruginous. The lesser upper wing coverts rufous with indistinct blackish bars, forming a *conspicuous reddish band the whole length of the forearm*. The median and greater upper wing-coverts like the remiges. Scapulars with the outer web wholly or largely pure white, giving the appearance of a broad

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white bar along sides of back, otherwise mottled gray and black, and with an interrupted black shaft-streak. Facial disk silver-gray, each feather with indistinct blackish crossbars. Disk edged at sides of neck by pale ferruginous feathers, which are subapically marked white and tipped black, forming a distinct black and ferruginous gorget, extending to nape, but interrupted on the breast. Feathers of breast and sides of neck whitish with broad dark gray tips, black shaft-streak and irregular black crossbars. Feathers of abdomen and flanks pure white or white faintly tinged ferruginous and with very broad black shaft-streaks and irregular narrow black bars. Under tail-coverts white with black shaft-streaks or immaculate. Tarsi feathered onto base of toes, white with scattered rufous macules. Bend of wing white. Under wing-coverts white with a few irregular black and ferruginous markings. In the dried skin the maxilla is horny-black; the mandible yellowish beneath, otherwise like the maxilla. Wing: 141.8; tail: 70.5; culmen from base: 19.5. First (outermost) primary equal to the eighth; second between fifth and sixth.

II

We have examined all the pertinent members of the genus known from Africa and eastern Asia and, in general, agree with the specific groupings of Stresemann (Mitt. Zool. Mus. Berlin **12** (1):191–195. 1925). We do not, however, accept the range of *malayanus*, as it has been understood in the past. *O. malayanus* is readily separable from *japonicus* by its much darker coloration (our 8 specimens are all in a red or brownish-red plumage) and by having the basal third of the tarsus naked; the third and fourth primaries are longest and the first (outermost) lies between the sixth and seventh or equals the seventh. *O. japonicus*, of which we have ample topotypical material, is much lighter, has both red and gray phases, and has the tarsus feathered to the base of the toes; the third and fourth primaries are longest, and the first lies between the sixth and the eighth.

A skin from Szechwan (April) and another from Yunnan (October) can not be matched in our series of *japonicus*, but they do agree in every particular with *malayanus* from the Malay Peninsula (where it is known only as a winter visitor). It seems probable that *malayanus* is a breeding form from southern China south to an unknown limit, occurring in winter as far as Malaya.

We have seen one specimen inseparable from Japanese *japonicus*, taken on the small island Koh Tao (Gulf of Siam) on the same day as a specimen of *malayanus*. This implies that *japonicus* may occur in winter anywhere within the range of *malayanus*. In view of this probability, Malayan specimens should be carefully compared with Japanese birds, especially the birds in gray phase recorded by Robinson.

We have also seen three winter specimens from northern and central Siam that are near to *japonicus* but differ in somewhat darker coloration, although they are still much lighter than *malayanus*.

Among the specimens sent us by Dr. Ernst Mayr are the birds from Bur-

ma and Assam, discussed by him in the Ibis for April, 1938, p. 313. With the more extensive comparative material before us, we have identified these birds quite differently.

"Otus scops modestus" from Dalu is not separable from specimens of *Otus sunia sunia* from Bengal.

The series of Assamese specimens that Dr. Mayr took to be typical *spilocephalus* is here tentatively referred to *O. scops sunia*, in the absence of definitely identified specimens of red phase *sunia*, but these four birds arouse the suspicion that they may be of an undescribed form. The bird from Dabahka, called *"Otus spilocephalus latouchi,"* is, in our opinion, true *Otus spilocephalus spilocephalus*, from which *latouchi* seems only doubtfully distinct.

In searching the literature with regard to the nomenclature of this group, we have discovered that *Pisorhina capensis grisea* Gunning and Roberts (Ann. Transvaal Mus. **3**:111. 1911. Bethulie, Orange Free State), is preoccupied by *Scops griseus* Jerdon (Madras Journ. Lit. Sci. **13**(2), no. 31:119. Dec. 31, 1844). We are not in position to pass on the validity of Gunning and Roberts' form, which, according to Chapin, "may perhaps prove separable," and therefore leave the renaming of it to some future student of the African scops owls.

Recently Junge (Treubia **16**(3):344. Aug., 1938) has considered *Otus umbra enganensis* Riley as a race of *O. sunia*. Previously Stresemann (Mitt. Zool. Mus. Berlin **12**:194. 1925) suggested with a question that *O. umbra* might be the same as *O. bakkamoena lempiji*. Chasen (*Handlist of Malaysian Birds*, p. 86, 1935) writes that *umbra* "can almost certainly be lumped with one of the other more widely spread Malaysian species, but as we have not seen either *umbra* or *enganensis* we can not attempt a wider nomenclature." We have examined the type specimens of *umbra* and of *enganensis* and find that they are not like any *O. s. malayanus* we have seen, and we consider them to form a specific group characterized by a massive bill and white bars on the chestnut flanks. In the type of *umbra* the first (outermost) primary is equal to the eighth, and the second is between the fifth and the sixth, whereas in *O. s. malayanus* the first is between the sixth and seventh, or equal to the seventh, the second between the fourth and the fifth. If Junge's Engano birds are really related to *sunia*, it may be that they represent an undescribed form. The type of *enganensis* has the primaries frayed, which prevents our giving its wing formula, and which also may account for the fact that Junge's bird had larger measurements than Riley gave for the type.

III

The form of *Otus bakkamoena* resident throughout Siam north of the province of Pattani (Malay Peninsula) has been considered identical with *lettia* of Nepal by all authors, except Chasen (*Handlist of Malaysian Birds*) who,

without comment, calls the birds of Peninsular Siam *condorensis* of Kloss (Journ. Siam Soc. Nat. Hist. Suppl. 8(2):81. 1930. [Pulau Condor, *ca.* 45 miles off the coast of Cochinchina]) and Riley (U. S. Nat. Mus. Bull. 172) who attributes to the same race a specimen from East Siam and another from Southwest Siam (where it occurs side by side with *"lettia"*).

O. condorensis was named on a series of only four specimens from an island possessing no other known endemic birds, the describer having at the time highly inadequate comparative material. The most northern specimen of *"lettia"* came from North Siam, other specimens from Raheng and Bangkok. Kloss was, moreover, misled by Stuart Baker into believing that *lettia* of Nepal and *lempiji* of Java are "practically the same in general tone of plumage"; accordingly, he diagnosed *condorensis* as being paler and larger than *lempiji*, paler and smaller than *lettia*.

The alleged size differences between *condorensis* and *"lettia"* are of the slightest according to Kloss's own measurements (the wing length of the former from 155 to 161 mm, of the latter from 158 to 167) and nonexistent when a good series of Siamese birds is examined. The alleged color differences do not appear at all in two birds from Cochinchina but do appear in odd individuals from Central and North Siam. There is some individual variation shown in the color of Siamese birds from any area, but all are considerably paler than *lempiji* and, to a less marked degree, paler than birds from Szechwan (and presumably Nepal also).

We have, unfortunately, not been able to examine *lettia* from Nepal. Birds from Szechwan have been called *glabripes* by authors, but they should at least show some approach to *lettia* for geographical reasons. They do, in fact, agree perfectly with a topotypical specimen of *glabripes* as well as with birds from Tongking. The further fact that we have found nothing in literature to indicate how *glabripes* may be distinguished from Nepalese *lettia* arouses some doubt as to the validity of the former, and we feel that the two races should be critically compared.

A series of 8 birds of both sexes (sexes alike in size) from Tongking and Szechwan have the wing length from 172 to 192 mm; a further series of 22 birds from Annam, Cochinchina, East Siam, Southeast Siam, Central Siam, West Siam, and North Siam have the wing length from 154 to 166 mm. Two birds from Southwest Siam measure 147 and 152 mm and seem to be approximating *lempiji*. Two specimens from Assam measure 161 and 167, thus falling into the size group of Indochinese birds.

The Fauna of British India, Birds, ed. 2 (4:427), embracing Assam and all Burma within the range of *lettia*, gives this race a wing length from 162 to 182 mm, and it seems reasonable to suppose that if only Nepalese birds had been measured even this slight overlap with Siamese birds would disappear. If *glabripes* prove indeed inseparable from *lettia*, the difference between Siamese birds and *lettia* will appear clearly from the measurements given above.

To the pale, short-winged birds of Annam, Cochinchina, Siam, ?Burma and ?Assam, we suggest that the name *condorensis* be applied.

Material examined:

Otus senegalensis griseus	2 specimens	
graueri	1 "	
hendersoni	2 "	
senegalensis	2 "	
ugandae	2 "	
cæcus	4 "	(incl. type)
distans	2 "	
Otus cyprius	series (A. M. N. H.)	
Otus scops elegans	" "	
japonicus	23 specimens	
sunia	9 "	
rufipennis	1 "	
balli	1 "	
malayanus	8 "	
scops	11 "	
pulchellus	9 "	
menadensis	5 "	
steerei	1 "	(type)
Otus spilocephalus spilocephalus	4 specimens	
latouchi	5 "	
siamensis	1 "	(paratype)
vulpes	2 "	
Otus rufescens malayensis	2 specimens	
rufescens	1 "	
Otus sagittatus	2 specimens	
Otus umbra umbra	1 specimen (type)	
enganensis	1 " "	
Otus cuyensis	2 specimens	
Otus bakkamoena semitorques	23 specimens	
pryeri	1 "	
glabripes	10 "	
bakkamoena	2 "	
condorensis	28 "	
lempiji	20 "	
mentawi	2 "	
fuliginosus	1 "	
whiteheadi	1 "	
Otus capnodes	3 specimens	
Otus rutilus	4 specimens	

ENTOMOLOGY.—*The North American empoascan leafhoppers of the* radiata *group (Homoptera: Cicadellidae).*[1] NANCY H. WHEELER,[2] U. S. Bureau of Entomology and Plant Quarantine. (Communicated by J. S. Wade.)

The species of leafhoppers treated in this paper are characterized by a strongly produced crown, tending to be bluntly pointed, with the median length almost as long as, or in some cases longer than, the narrowest interocular space. The species of this group range in length from 2.75 to 3.75 mm. They are frequently well marked with distinctive color patterns and are usually easily distinguishable externally. However, from a study of the group in general, and from an examination of extensive western collections in particular, it appears obvious that several of the closely related species can be differentiated readily and accurately only by examination of the structures of the internal male genitalia.

Some of the species here discussed were originally included by DeLong[3] in the subgenus *Idona*, which he established with *minuenda* Ball[4] as the type, on the basis of the shape of the head. In addition to the type, he included in this subgenus *panda* DeLong, *junipera* DeLong, *elongata* DeLong, *rufa* DeLong, *tincta* DeLong, *morrisoni* Hartzell, *radiata* Gillette, and *mexicana* Gillette. Later, McAtee[5] pointed out reliable venational characters and raised *Idona*, with *minuenda* as the type, from subgeneric to generic rank, stating that "some of the other species certainly, and all of them probably, can well remain in the typical subgenus of *Empoasca* Walsh."

In view of the uncertain status of this group, a careful examination has been made of all available type material of the species involved. As a result, some synonymical changes are recorded and the group, of which *radiata* is a typical example, is redefined and considered as a part of the subgenus *Empoasca* Walsh. Only four of the original species are included in this *radiata* group, and, on the basis of the characters defining the group, *elongata*, *morrisoni*, and *panda* (because of their larger size and more rounded crown) are excluded and referred to the *fabae* group; *mexicana* Gillette, which will have as a

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[2] In the preparation of this paper the writer has had access to the U. S. National Museum collections and expresses her thanks to P. W. Oman, of the Division of Insect Identification, Bureau of Entomology and Plant Quarantine, for his cooperation and helpful criticism, and to Dr. R. H. Beamer, Dr. D. M. DeLong, and E. P. Van Duzee for loan of valuable material for comparison.

[3] U. S. Dept. Agr. Tech. Bull. **231**: 1–59. 1931.

[4] Proc. Biol. Soc. Washington **34**: 23–24. 1921.

[5] Proc. Zool. Soc. London, 1934, pt. 1: 107. 1934.

synonym *bitubera* DeLong, 1932,[6] is referred to the *alboneura* group; while *occidentalis*,[7] subsequently described by DeLong and Davidson, is placed in the *radiata* group. Another species, *ruficeps*, described in 1917 by Van Duzee from external characters only, apparently belongs to this group but was not included by DeLong in his revision of the genus.

This paper includes the description and illustrations of the internal male genital characters of *ruficeps*, together with those of five other species of the *radiata* group, four of them new to science. Three illustrations of each species are given, depicting both lateral and ventral views of the male genital capsule, and the ventral view of the sternal apodemes, and each drawing shows an enlargement of approximately 70 diameters.

The following key is presented as an aid in the separation of the species of the *radiata* group[8] now known to occur in North America.

KEY TO THE SPECIES OF THE RADIATA GROUP

A. Fore wing without definite gray or brown spots, and consequently without a mottled appearance.
  B. Posterior margin of seventh sternite of female with a median slightly produced lobe or tooth and a slight indentation on each side of it. General color olivaceous-green ..... *junipera* DeLong
  BB. Posterior margin of seventh sternite of female not as above. General color yellowish, orange, or testaceous-green.
    C. Fore wing with orange or brownish stripes along the claval suture. Lateral processes, in ventral view, with apices curved laterad ..... *radiata* Gillette
    CC. Fore wing without stripes along claval suture. Lateral processes, in ventral view, with apices not curved laterad.
      D. Fore wing tinged with testaceous. Lateral process, in ventral view, terminating in a small hook curved mesad ..... *tincta* DeLong

[6] Ohio Journ. Sci. 32(4): 395. 1932.
[7] Ohio Journ. Sci. 35(1): 32–33. 1935.
[8] After this manuscript was submitted for publication, Davidson and DeLong (Ohio Journ. Sci. 39(2): 110–118. 1939) published descriptions of *Empoasca dorothyi*, *E. galluza*, and *E. ancistra*, which apparently belong to the *radiata* group. Subsequent study of male paratypes of these species indicates that the first two bear a close resemblance, both externally and internally, to the species herein described as *E. crepidula*. The single specimen of each species available for examination may be differentiated by the relative length of the lateral process and the curvature of the apical portion of this process. In *dorothyi* and *galluza*, the lateral process in ventral view is longer than in *crepidula*, but the apical portion is less curved mesad in *dorothyi* than in either *crepidula* or *galluza*. It is possible that *crepidula* may prove to be an extreme variation of *dorothyi* and that a study of a longer series in each case, particularly of abundant material from northern Arizona, may show that *dorothyi*, *galluza*, and *crepidula* are variants of a single species. The species described as *ancistra* is apparently close to what has been identified as *radiata* Gillette, but, since the male type of *radiata*, supposedly in the U. S. National Museum collection, can not be located, there is some question as to the proper identity of that species and decision in this matter must await further study.

DD. Fore wing tinged with smoky green or orange. Lateral process, in ventral view, without terminal hook.
E. Fore wing tinged with smoky green across center of clavus and apex, giving a banded appearance. Posterior margin of seventh sternite of female with a shallow median quadrangular emargination ..... *occidentalis* DeLong and Davidson
EE. Fore wing tinged with orange, without banded appearance. Posterior margin of seventh sternite of female produced and rounded, without median quadrangular emargination.
F. Lateral process, in lateral view, relatively short and bluntly pointed ..... *crepidula*, n. sp.
FF. Lateral process, in lateral view, long and sharply pointed ..... *acuminata*, n. sp.
AA. Fore wing with definite gray or brown spots, giving a mottled appearance.
B. Head with a network of red pigmentation. Fore wing greenish white mottled with gray.
C. Lateral processes, in ventral view, crossed medially, their apices produced and curved inward ..... *erythrocephala*, n. nom.
CC. Lateral processes, in ventral view, not crossed medially, their apices bluntly rounded and divergent ..... *rubrarea*, n. sp.
BB. Head without a network of red pigmentation. Fore wing yellowish green mottled with orange, gray, or brown.
C. Lateral processes, in ventral view, crossed medially, their apices produced and overlapping ..... *ruficeps* Van Duzee
CC. Lateral processes, in ventral view, not crossed medially.
D. Lateral process, in lateral view, with apex sharply pointed and curved dorsad .... *rubrarea* var. *indistincta*, n. var.
DD. Lateral process, in lateral view, with apex bluntly pointed and curved ventrad ..... *delta*, n. sp.

Empoasca crepidula, n. sp. Fig. 1

Superficially resembling *occidentalis* but more yellowish and lacking banded appearance, and with a shorter lateral pygofer process and a small slipperlike spine. Length 3.75 mm.

External characters.—General color dull yellowish green tinged with orange. Crown irregularly marked with indistinct white areas. Pronotum with three large white spots along anterior margin. Scutellum with a median white stripe and a large white dot in center near apex, with a much smaller dot on each side. Fore wing subhyaline, with apex faintly fuscous. Seventh sternite of female with posterior margin slightly produced and rounded not notched medially.

Male internal structures.—Lateral process relatively short, extending only slightly beyond tip of style; in lateral view curving dorso-caudad, with apex appearing bluntly pointed; in ventral view broadly sinuate, with apical half curving gradually mesad and tapering to a point. Dorsal spine narrow at base and broadening into a small sharply pointed slipperlike shape with apex directed ventrocephalad. Sternal apodemes long and slender, bluntly rounded distally.

Described from one male and two females collected at Oak Creek Canyon, Ariz., August 9, 1932, by R. H. Beamer.

Holotype male and allotype and paratype females deposited in the Snow Entomological Collection, Lawrence, Kans.

Empoasca acuminata, n. sp. Fig. 2

A dull yellowish-green species, with long-pointed lateral process. Length 3.2 mm.

External characters.—General color dull yellowish green tinged with orange. Crown with median white line constricted at middle and with two oblique white dashes on each side near eye. Pronotum with four irregular white spots along anterior margin, median pair almost contiguous. Scutellum with median white area and three white spots near apex along incised line. Fore wing subhyaline, tinged with orange. Seventh sternite of female with posterior margin produced and rounded.

Male internal structures.—Lateral process long and pointed, slender at base and gradually broadening toward middle, with apical fourth tapering to long slender point directed caudad. Dorsal spine broad at base, with apical portion bluntly rounded and extending ventrad. Sternal apodemes large and saclike.

Holotype male, allotype female, and 12 male and 8 female paratypes from Nogales, Ariz., October 20, 1937, P. W. Oman, collector.

Type, U. S. N. M. no. 53285. Four paratypes deposited in collection of the entomological laboratory of the U. S. Bureau of Entomology and Plant Quarantine, Arlington Experiment Farm, Arlington, Va.

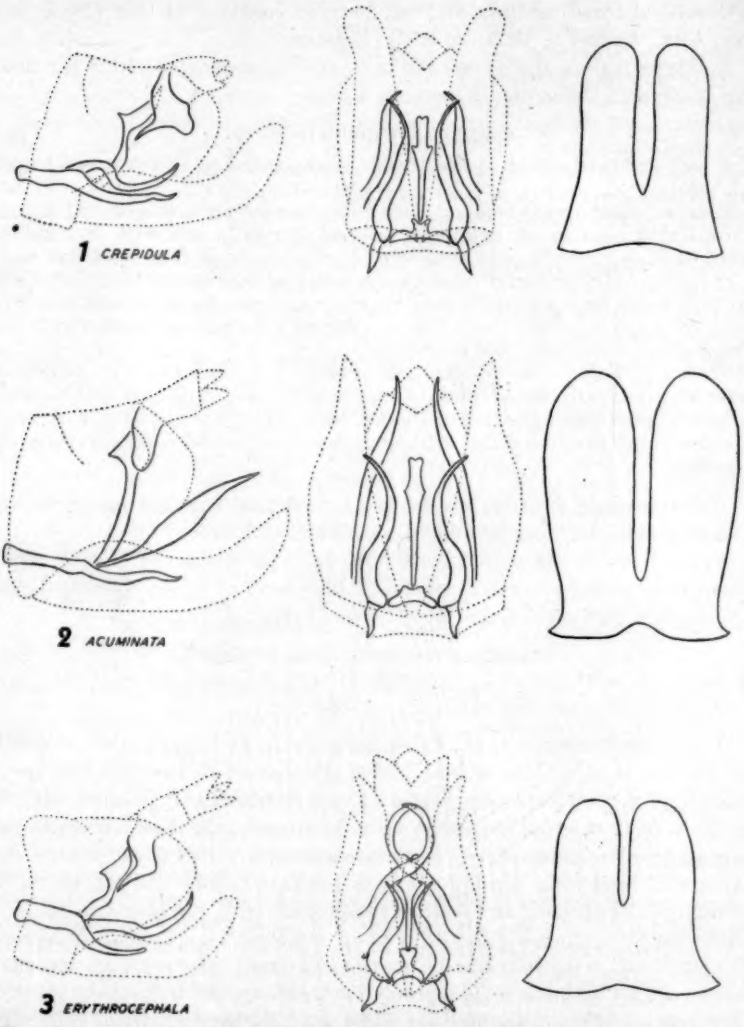
Empoasca erythrocephala, new name Fig. 3

Empoasca rufa DeLong (*nec* Melichar, Homop.-Fauna v. Ceylon: 212. 1903), U. S. Dept. Agr. Tech. Bull. 231:53–54. 1931.

From specimens collected at Pasadena, Calif., DeLong, in 1931, described as *Empoasca rufa* DeLong (*nec* Melichar) a small (3.2 mm) white species with reddish mottling on the head and with crown bluntly pointed. Melichar in 1903, from external characters only, had previously described as *E. rufa*, a scarlet-red, foreign species, 4 1/5 mm in length, illustrating the head, fore wing, and hind wing. From a study of the illustrations and the description of Melichar's species, and from a comparison with specimens in the U. S. National Museum collection, which appear to be that species, *rufa* Melichar is considered representative of an oriental group of *Empoasca* having no close relation with the *radiata* group. DeLong's species is therefore given the new name *erythrocephala* and is reillustrated, for the purpose of comparison with other closely related species, from specimens collected by R. H. Beamer at Claremont, Calif. The types of *rufa* DeLong are in the collection of E. D. Ball.

Empoasca rubrarea, n. sp. Fig. 4

Superficially resembling *erythrocephala*, but with a shorter dorsal spine and the lateral processes in ventral view not crossed in the middle. Length 2.75–3 mm.



Figs. 1–3.—Lateral and ventral views of male genital capsule and ventral view of sternal apodemes of (1) *Empoasca crepidula*, n. sp., (2) *E. acuminata*, n. sp., and (3) *E. erythrocephala*, new name. × ca. 70.

External characters.—General color pale greenish white, with the network of bright red pigmentation on upper portion of face and crown less heavily outlined than in *erythrocephala;* irregularly marked with red on pronotum and scutellum and on base and costal margin of fore wing. Fore wing also flecked with small gray spots, the larger spot on middle of clavus along com-

missural line much darker and more distinct than in *erythrocephala;* apex fuscous, with pale nervures. Seventh sternite of female slightly produced and rounded posteriorly.

Male internal structures.—Lateral process in lateral view relatively stout, curving dorso-caudad, with dorsal margin slightly concave at distal portion, terminating in a sharply pointed apex directed dorsad; in ventral view curving mesad, then caudad, with distal portion slightly enlarged and bluntly rounded. Dorsal spine rather indistinct, slightly broader at base, deeply concave on cephalic margin and curved to sharply pointed apex directed ventrocephalad. Aedeagus broad distally. Sternal apodemes medium sized, bluntly rounded distally.

Described from a series of 53 males and 93 females collected by R. H. Beamer, July 24, 1935, in Santa Barbara County Park, 13 miles east of Nipomo, Calif., labeled "Nipomo, Cal." There are also at hand collections by R. H. Beamer consisting of one male from Claremont, Calif., July 29, 1935, and 14 males and 20 females from Topango Canyon, Calif., August 5, 1938.

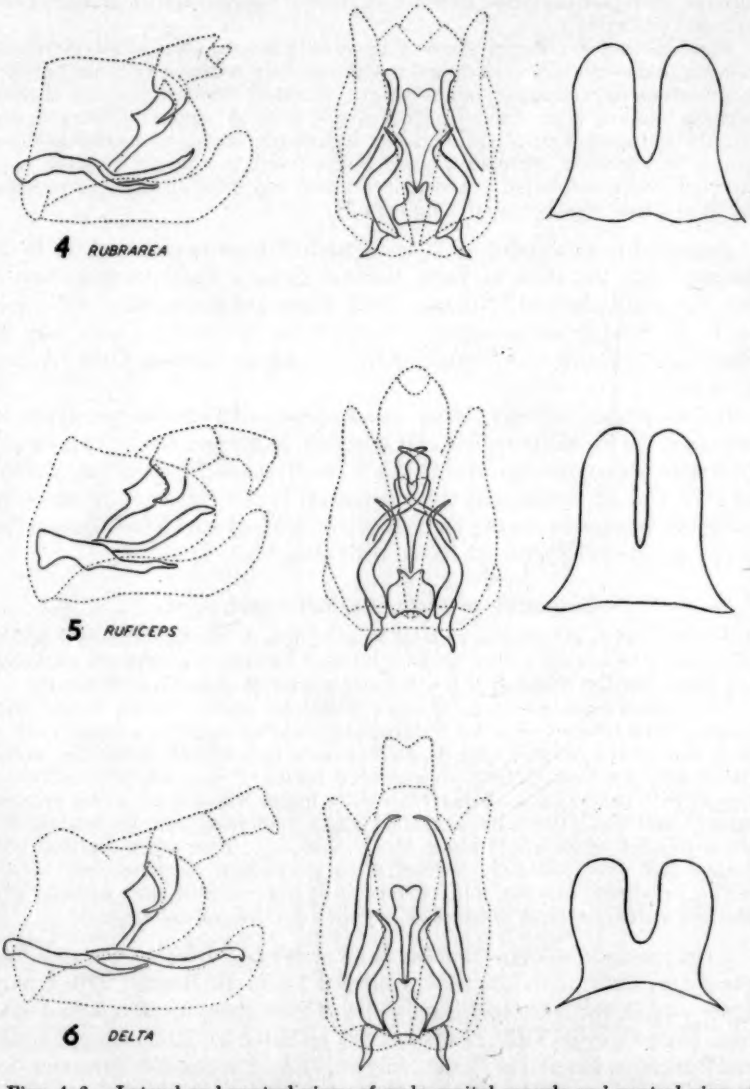
Holotype male, allotype female, and 25 male and 45 female paratypes deposited in the Snow Entomological Collection, Lawrence, Kans.; 15 male and 15 female paratypes deposited in the U. S. National Museum (no. 53286); 12 male and 32 female paratypes deposited in the collection of the entomological laboratory of the Bureau of Entomology and Plant Quarantine at the Arlington Experiment Farm, Arlington, Va.

Empoasca rubrarea var. indistincta, n. var.

Agreeing with *rubrarea* in general form and with identical internal genital structures, but more yellowish in color and lacking the network of bright red pigmentation on head and other red markings. Length 2.75–3 mm.

External characters.—General color yellowish green. Crown tinged with orange, with four small white spots along anterior margin, a larger spot on each side near eye, and a white median area constricted in middle, sometimes forming two distinctly separated spots. Pronotum and scutellum tinged with orange, the former with three larger white spots along anterior margin and the latter with a median white spot near anterior margin and three smaller white spots along the incised line. Fore wing mottled with orange and more sparsely flecked with gray than *rubrarea,* but with a similar, distinct, fuscous spot on middle of clavus, and apex fuscous with pale nervures. Seventh sternite of female like that of *rubrarea.*

Holotype male, allotype female, and 8 male and 8 female paratypes from Monterey, Calif., July 22, 1935, collected by R. H. Beamer. Other paratypes as follows: One male from Cajon, Calif., June 6, 1935, and 1 male from Mint Canyon, Calif., June 7, 1935, collected by P. W. Oman; 1 male and 2 females, Beaumont, Calif., July 26, 1933, 2 males and 2 females, San Gabriel Canyon, Calif., July 27, 1935, 4 males and 8 females, Monrovia, Calif., July 27, 1935, and 4 males, San Diego, Calif., August 7, 1935, all collected by R. H. Beamer; 6 males and 6 females collected by Jack Beamer, Monterey, Calif., July 22, 1935.



Figs. 4–6.—Lateral and ventral views of male genital capsule and ventral view of sternal apodemes of (4) *Empoasca rubrarea*, n. sp., (5) *E. ruficeps* Van Duzee, and (6) *E. delta*, n. sp. × ca. 70.

Holotype male, allotype female, and 15 male and 14 female paratypes deposited in the Snow Collection, Lawrence, Kans.; 6 male and 6 female paratypes deposited in the U. S. National Museum (no. 53287); and 6 male and 6 female paratypes in the collection of the entomological laboratory of the Bureau of Entomology and Plant Quarantine, Arlington Experiment Farm, Arlington, Va.

Empoasca ruficeps Van Duzee Fig. 5

Empoasca ruficeps Van Duzee, Proc. California Acad. Sci. 7 (ser. 4): 304–305. 1917.

External characters.—Small, yellowish green, mottled with brown, with pronotum and scutellum marked with sanguineous-brown, and apex of fore wing deeply infuscated, with strong pale nervures. Length 3.5 mm.

Male internal structures.—Lateral process in lateral view curving dorsocaudad, basal half with sides almost parallel margined, apical half slightly broader, terminating in a blunt point directed caudad; in ventral view the lateral processes are long, curving first mesad and crossing near middle, extending slightly laterad, then caudad, broadening distally, then tapering to bluntly pointed, overlapping apices directed laterad. Dorsal spine broad at base, deeply concave on cephalic margin, with sharply pointed apex directed cephalad. Aedeagus narrow at base, enlarged distally. Sternal apodemes medium sized, bluntly rounded distally.

Van Duzee described *ruficeps* from 30 specimens collected at Los Altos, Calif., July 26, 1916, on pitcher-sage (*Sphacele colycina*), and at Westpoint, Mount Tamalpais, 1,300 feet elevation, August 16, 1916. The drawings (Fig. 5) were made after examining male and female paratypes received from Van Duzee, 1 female collected at Mount Diablo, Calif., June 21, 1935, by Oman and compared by him with the type, and 5 males and 5 females collected at Lockwood, Calif., July 25, 1935, by R. H. Beamer.

Empoasca delta, n. sp. Fig. 6

Resembling *ruficeps* somewhat in general appearance, but smaller, with pronotum and scutellum yellowish green and less marked with sanguineous-brown, and apex of fore wing less deeply infuscated. Genital characters distinct. Length 2.5–2.75 mm.

External characters.—Crown tinged with orange, with a pale spot on each side near eye and a pale median area, sometimes constricted in middle, forming a pale spot at apex and one at middle of posterior margin. Pronotum yellowish green, with three paler areas near anterior margin, the middle one outlined by a dark line on each side and the lateral areas each surrounded by several dark-brown dots. Scutellum yellowish green, with a median white area and a transverse row of three pale points just below the incised line, the apex terminating in a conspicuously dark-brown point. Fore wing subhyaline, yellowish green, mottled with brown, sometimes with orange, with a small rufous-brown spot near tip of clavus; apex fuscous, with pale nervures. Posterior margin of seventh sternite of female rather strongly produced from prominent lateral angles.

Male internal structures.—Lateral process long, curved, relatively stout, with sides parallel to near apex; in lateral view distal portion slightly en-

larged and terminating in a short fingerlike process curved downward; in ventral view distal portion angularly bent on inner margin and curved on outer margin to sharply pointed apex directed mesad. Dorsal spine stout, tapering to a sharp point, curved cephalad. Aedeagus broad distally. Sternal apodemes medium sized, bluntly rounded distally, with apices more widely separated than in *ruficeps*.

Holotype male, allotype female, and numerous paratypes of both sexes from Delta, Calif., June 28, 1935, P. W. Oman, collector. Types, U.S.N.M. no. 53288. Twelve paratypes deposited in collection of the entomological laboratory of the Bureau of Entomology and Plant Quarantine, Arlington Experiment Farm, Arlington, Va.

Empoasca mexicana Gillette

Empoasca mexicana Gillette, Proc. U. S. Nat. Mus. **20**(1138): 737–738. 1898.
Empoasca bitubera DeLong, Ohio Journ. Sci. **32**(4): 395. 1932. (New synonymy.)

As previously mentioned, *mexicana*, because of the more rounded crown and the pale nervures of the fore wing, belongs in the *alboneura* group, but the writer treats it here in order to establish the synonymy indicated.

The original description of *mexicana* by Gillette was based on 5 females collected near Veracruz, Mexico, type no. 3430, U. S. National Museum. Later DeLong[9] redescribed specimens "as apparently this species" and illustrated the male genitalia from a series in the U. S. National Museum collection consisting of 5 females and 3 males collected at Marfa, Tex., June 5, 1908, by Mitchell and Cushman, stating that Gillette's type could not be located in the National Museum. From an examination of this series now extant, consisting of 1 male (dissected), 3 females, and 2 specimens with abdomens missing, the external markings and internal structures of the male were found to be identical with those described and figured later by DeLong for *bitubera*. *Empoasca bitubera* is therefore placed as a synonym of *E. mexicana* Gillette.

[9] U. S. Dept. Agr. Tech. Bull. **231**: 56–57. 1931.

MAMMALOGY.—*A new badger from Sonora.*[1] E. A. GOLDMAN, U. S. Bureau of Biological Survey.

The badgers of the widely dispersed species, *Taxidea taxus*, are divisible into several closely allied geographic races. One of these, hitherto unrecognized, from near the southern known limit of the species along the eastern side of the Gulf of California is described as follows:

Taxidea taxus sonoriensis, subsp. nov.

Type.—From Camoa, Rio Mayo (about 15 miles above Navojoa), Sonora, Mexico. No. 96211, ♂ young adult (frontoparietal sutures fused), U. S. National Museum (Biological Survey collection); collected by E. A. Goldman, November 29, 1898. Original number 13263.

[1] Received June 1, 1939.

Distribution.—Lowland plains region of southern Sonora; limits of range undetermined.

General characters.—A rather small, dark-colored subspecies with conspicuously blackish chin; white median dorsal stripe ending near shoulders, or extending as a very narrow, more or less interrupted line to lower part of back, but not normally reaching over rump; nasals narrowing abruptly posteriorly at point of contact between maxillae and frontals. Closely allied to *Taxidea taxus berlandieri* of western Texas, but general color slightly darker, more extensively mixed with black; chin usually distinctly blacker; nasals narrowing more abruptly at point of contact between maxillae and frontals. Very similar to *Taxidea taxus infusca* of southern Lower California, but white median dorsal stripe less continuous posteriorly (extending over rump in *infusca*); chin usually distinctly blacker; cranium flatter and differing in detail.

Color.—Type: Facial area, including eyes, and forehead (except median line), and patches on sides of head in front of ears black as usual in the species; irregular white markings under and behind eyes confluent with white of under parts; white median line extending from middle of face to near shoulders; general dorsal area and sides of body a coarse mixture of buff, black, and white, the individual hairs pinkish buff at base, becoming black subterminally and white at tip; general abdominal area light buff thinly streaked with black, becoming pure white along a narrow median line; under side of neck pure white; chin and spot at base of median tuft of vibrissae on throat blackish; ears blackish, edged with white; fore and hind limbs black; upper side of tail similar to back, but basal color of hairs more cinnamon-buff, under side of tail more predominantly cinnamon-buff.

Skull.—Very similar in size and general form to that of *berlandieri*, but nasals narrowing more abruptly at point of contact between maxillae and frontals (in *berlandieri* the nasals are more evenly V-shaped, tapering gradually to a point posteriorly); mastoids more rounded and fully inflated, dentition about the same. Compared with that of *infusca* the skull is somewhat broader and flatter, the brain case less highly arched, basioccipital broader; nasals broader, less evenly tapering posteriorly (differing to about the same extent as from *berlandieri*); auditory bullae less bulging below level of basioccipital; dentition similar.

Measurements.—Type: Total length, 662 mm; tail vertebrae, 122; hind foot, 100. An adult female topotype: 625; 110; 107. *Skull* (type and an adult female topotype, respectively): Condylobasal length, 114.7, 113; zygomatic breadth, 69.8, 70.9; breadth of braincase (across mastoid processes), 70.7, 69.5; height of braincase (over auditory bullae), 48.5, 48.4; interorbital breadth, 24.2, 25.2; postorbital constriction, 27.4, 28.6; palatal constriction, 14.1, 13.5; maxillary tooth row (alveoli), 35.8, 38.5; crown length (outer side) of upper carnassial, 11.4, 12.5; crown width of upper carnassial, 8.8, 9.8.

Remarks.—Taxidea taxus sonoriensis appears to be most closely allied to *T. t. berlandieri*, with which it doubtless intergrades on the north. One of the most distinctive cranial details noted is the abruptly narrowing outline of the nasals, which is quite uniform in the series of topotypes.

Specimens examined.—Total number, 6, all from Sonora, as follows: Camoa (type locality), 5; Costa Rica Ranch (about 40 miles southwest of Hermosillo), 1 (skull only).

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1138TH MEETING

The 1138th meeting was held in the Cosmos Club Auditorium, Saturday, October 8, 1938, President HECK presiding.

Program: STERLING B. HENDRICKS, U. S. Bureau of Chemistry and Soils: *Random structures and water sorption in clays.*—The crystal structures of a number of minerals related to the micas were described, and models illustrating some of their structures were exhibited. Three general problems were then discussed: (1) Why is kaolin, $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$, polymorphic and why is aluminum only slightly replaceable by iron or magnesium in the kaolins? (2) What is the structure of the hydrates of the clay minerals? (3) Why do some minerals related to talc show diffuse reflections and what is the connection between this property and random factors present in the structures? (*Author's abstract.*)

R. W. GORANSON: *On the electrical properties of multilayers.*—Experiments were described which demonstrated that the electrical properties of multilayers of stearic acid, as formed by the Langmuir-Blodgett method, were caused by the adsorption of metallic ions from the substrate. It was shown that these ions were present in the multilayer as a volume distribution. Evidence was presented as to the existence of a marked influence of the speed of building the multilayers on the electrical properties. While adsorbed positive charges were always present, at speeds in excess of a certain value, negative frictional charges also developed. The frictional charges were caused by the relative motion of film and aqueous substances. (*Author's abstract.*)

The first paper was discussed by Messrs. ROLLER, BRICKWEDDE, and TELLER; the second one by Messrs. MOHLER, BRICKWEDDE, and GIBSON.

1139TH MEETING

The 1139th meeting was held in the Cosmos Club Auditorium, Saturday, October 22, 1938, President HECK presiding.

Program: N. SMITH, National Bureau of Standards: *Regular characteristics of the ionosphere during half a sunspot cycle.*—The sun is the principal source of the energy that produces the ionization in the earth's upper atmosphere. The increase in solar activity from the sunspot minimum in 1933 to 1938 resulted in large increases in this ionization. During this period the maximum ionization density of the E layer, at about 130 km in height, increased by a ratio of 1.55 to 1, and the maximum ionization density of the F_2 layer, at about 300 to 400 km in height, increased by a ratio of 4 to 1. This means an increase in the solar radiation responsible for the E layer by a ratio of about 2.4 to 1 and for the F_2 layer by a ratio of about 16 to 1. The ionization of the E layer has followed fairly well in phase with the sunspot cycle, whereas the ionization of the F_2 layer showed somewhat of a lag.

Superimposed on this long-period increase of ionization were the more or less regular diurnal and seasonal variations. The diurnal and seasonal variations of E layer ionization for the most part accord quite well with the simple theory of ionization by ultraviolet radiation from the sun, but the variations in F_2 layer ionization show that other factors must be taken into consideration. (*Author's abstract.*)

S. S. KIRBY, National Bureau of Standards: *The sporadic-E layer of the ionosphere.*—The sporadic-E layer is a term used to designate a layer of the ionosphere which reflects radio waves from a height about that of the normal-E layer but at sporadic intervals of time and frequently at scattered geographical locations although occasionally the effect is general over wide areas. The reflections occur at much higher frequencies than from the normal-E layer and sometimes at higher frequencies than from the F_2 layer. As additional contrasts to the normal-E and F_2 layers, the sporadic-E has no smooth diurnal and seasonal variations but occurs both day and night principally in summer, does not exhibit marked critical frequency effects, and is often semitransparent over wide frequency ranges. These effects have been indicated by vertical incidence ionosphere measurements.

The sporadic-E layer is responsible for moderately long distance propagation of ultra-high frequencies at sporadic intervals of time and usually over scattered geographical areas, but occasionally over wide areas. These results have been indicated chiefly by amateur transmissions at 56 Mc/s over distances from several hundred to 2,000 or more kilometers.

Both the vertical-incidence ionosphere measurements and the long-distance transmissions convey the impression that sporadic-E layer is formed at sporadic time intervals in clouds which are usually very much limited in geographical distribution but sometimes are widespread.

Data have been compared and no definite relations have been found between the occurrence of sporadic-E layer and thunderstorms, ionosphere storms, or fadeouts at Washington.

The sporadic-E layer does not appear to be an intense ionization produced directly by sporadic solar activity. A more reasonable explanation is that the effect is caused by reflections from the sharp boundary of a layer of moderate ionization density and that the direct cause of the sharp boundary is largely terrestrial. Since the normal-E layer has a fairly sharp boundary the change in distribution of ions would not have to be very great. (*Author's abstract.*)

The papers were discussed by Messrs. BRICKWEDDE, MCNISH, MARIS, HUMPHREYS, MOHLER, BROMBACHER, MAXWELL, SEATON, and VESTINE.

1140TH MEETING

The 1140th meeting was held in the Cosmos Club Auditorium, Saturday, November 5, 1938, President HECK presiding.

Program: WALTER RAMBERG: *Flexural vibrations of rotating propeller blades.*—Flexural vibrations of propeller blades are believed to be an important cause of the propeller failures that have occurred from time to time under flight conditions. A previous study of nonrotating propeller blades which had been set to vibrate flexurally had shown that the measured natural frequencies and stress distributions agreed with those given by considering the propeller blade as a straight slender beam of variable section. A report of this work was presented before the Society on April 13, 1935.

The present paper extends the theoretical portion of this work to include the effect of rotation at service speeds. The integral equation was derived for a propeller blade that vibrates flexurally with a symmetrical mode. This equation was solved for two aluminum alloy propeller blades of typical design vibrating with the fundamental mode and with the second harmonic mode. The two extreme conditions of rigid clamping at the hub and of zero clamping at the hub were considered.

Rotation was found to shift the maximum stress per unit tip deflection toward the hub and it raised the value of this maximum up to 10 percent. Rotation caused an increase in natural frequency that could be predicted closely by substituting the deflection curve for no rotation in Lord Rayleigh's expression for the natural frequency of an elastic system. The model rules due to Theodorsen were discussed which show that the stress distribution and the frequency for flexural vibrations in a given blade may be determined directly provided that this blade is affine in dimensions to a type blade for which solutions are already available. The need for experimental work was emphasized to check the assumptions of the theory and to determine which natural modes of the propeller-crankshaft system are most dangerous in leading to fatigue failure. (*Author's abstract.*)

L. B. TUCKERMAN: *Heterostatic loading and critical astatic loads.*—Southwell has shown how, in some cases, it is possible to compute the critical astatic load, i.e., the elastic buckling load, of a structure from measurements of its heterostatic deflections at lower loads. The history of the theory of heterostatic loading and Southwell's method is briefly reviewed. Westergaard's general theory is then applied to the problem. It is shown that Southwell's method and Lundquist's modification of it are theoretically accurate for results of measurements which are proportional to the value of any one astatic parameter. These measurements need not be deflection measurements but may be strain measurements or, theoretically, measurements of any effect linearly dependent upon the deformation. Further, the parameter need not be the parameter corresponding to the lowest critical load but theoretically may correspond to any higher critical load.

Southwell's method is thus useful in cases where measurements within the elastic range can be made to depend primarily upon the change of a single astatic parameter. If the measurements are affected appreciably by changes in other parameters, the critical load computed by Southwell's method or Lundquist's modification may be considerably in error. A combined numerical and graphical method of computation is outlined which by successive approximations gives more accurate results in such cases. Finally experimental results are given in which the second and third critical loads of a "round end" Euler column are computed from strain gage measurements taken at loads below the first critical load. (*Author's abstract.*)

The first paper was discussed by Messrs. TUCKERMAN and NELSON; the second one by Messrs. TELLER, DEMING, RAMBERG, and NELSON.

1141ST MEETING

The 1141st meeting of the Society was held in the Cosmos Club Auditorium, Saturday, November 19, 1938, President HECK presiding.

Program: J. W. BEAMS, University of Virginia: *Some applications of high rotational speeds.*—A few high-speed vacuum-type air-driven centrifuges are described and their operating characteristics given. Their applications to such problems as the separation of isotopes, purification of material, determination of molecular and particle weights and sizes, are discussed. A brief description is also given of the new magnetically-supported electrically-driven vacuum-type centrifuge. Like the air-driven centrifuge, the maximum rotational speed of this electrically-driven magnetically-supported centrifuge is limited only by the bursting strength of the centrifuge. Six-inch rotors have been spun at speeds above 1,000 rps. The speed does not vary by more than 1 rps. for periods of six hours, and the temperature of the rotor remains very constant. The technique of spinning long tubes about a

vertical axis in a vacuum to very high speeds is briefly described, and their use as centrifuges for gases and liquids is outlined. The material to be centrifuged enters the spinning tube at one end and is collected in light and heavy samples at the other. (*Author's abstract.*)

An informal communication on "Natural Diffraction Spectra in Agates" was presented by J. W. McBURNEY.

1142D MEETING

The 1142d meeting, constituting the 68th annual meeting, was held in the Cosmos Club Auditorium, Saturday, December 3, 1938, President HECK presiding.

The treasurer reported that the income from dues and from interest on investments was $1,366.19 and that the expenditures, other than investments, were $1,313.83, leaving a net surplus of $52.36 on ordinary expenses. The ordinary expenditures were at the rate of $4.27 per member. The treasurer reported that, with the approval of the General Committee, he had sold certain securities of the Society, reinvested a portion of the proceeds in other securities, and is conducting negotiations for the investment of the balance in other securities.

The secretaries' joint report showed an active membership as of December 1, 1938, of 308, of whom the following were elected during the year: RAY L. DRISCOLL, LESTER R. FRANKEL, CHRISTOS HARMANTAS, ENOCH KARRER, R. B. KENNARD, PAUL S. ROLLER, OTIS W. SWAINSON, E. H. VESTINE, DAVID WERTMAN, and GLADYS WHITE. The following were elected in 1937 and qualified in 1938: WESTLEY F. CURTIS, THEODORE B. GODFREY, H. F. KAISER, FOREST R. MOULTON, FRANCIS W. STRUTHERS, ROLLA H. TAYLOR, and MERLE A. TUVE.

The annual report of the General Committee described the outstanding items of business that had come before the General Committee during the year as follows: (a) Changes in the bylaws of the General Committee relative to the conduct of elections; (b) necessity of curtailment of ordinary expenses due to decreased income from investments; and (c) elimination of an item of expense for subscription to the JOURNAL OF THE WASHINGTON ACADEMY OF SCIENCES for members of the Society who are not members of the Academy. These items were discussed by Messrs. DRYDEN, HUMPHREYS, SEEGER, and HOWE.

Changes in the bylaws relative to the conduct of elections were adopted as recommended by the General Committee and were made retroactive.

W. D. LAMBERT made some comments and recommendations regarding the preparation and mailing of ballots and instructions to voters. This matter was discussed by Messrs. TUCKERMAN, WERTHEIMER, MOHLER, MCNISH, SILSBEE, and BLAKE.

The following officers were declared elected for the year 1939: *President*, F. G. BRICKWEDDE; *Vice-Presidents*, R. E. GIBSON and H. E. MCCOMB; *Recording Secretary*, R. J. SEEGER; *Treasurer*, H. F. STIMSON; and *Members-at-Large of General Committee*, WALTER RAMBERG and A. G. MCNISH.

Program: HERBERT G. DORSEY: *Sono radio buoys for hydrographic surveying.*—These buoys were developed by the U. S. Coast and Geodetic Survey to serve as inexpensive hydrophone stations in radio acoustic ranging.

Each sono radio buoy consists of one or more hollow steel drums to contain the electrical apparatus and furnish buoyancy to float the superstructure and counterweight.

In one of these drums there is an audio amplifier, designed primarily for frequencies below 200 cycles, a keying tube and a crystal controlled radio transmitter. A total of five or six 2-volt tubes is used, all biased to cut off so that no B battery current is required, except about two milliamperes screen grid current, when no signal is received. The filaments are kept heated continuously by dry batteries. Bomb signals are received from the water by an electromagnetic hydrophone, suspended below the sono radio buoy, the impulse of which is amplified by the audio amplifier, actuating the keying tube which furnishes screen grid current to the transmitting tube, sending a short radio signal from the antenna supported on the superstructure.

The time elapsed between firing the bomb by the surveying ship and the return of the radio dash is measured to 0.01 second on the ship's recording chronograph and by such returns from two or more sono radio buoys placed in known locations the ship's position can be located with far greater accuracy than by any method other than visual fixes.

These sono radio buoys have now been successfully used by the U. S. Coast and Geodetic Survey for the past three seasons and their use has been adopted by the U. S. Naval Hydrographic Office during the past year. (*Author's abstract.*)

In discussing this paper Mr. P. A. SMITH presented a slide showing some of the detailed hydrographic work that has been done recently by this method off the eastern shore of the United States.

H. E. MCCOMB, *Recording Secretary*

1143D MEETING

The 1143d meeting was held in the Cosmos Club Auditorium, Saturday, December 17, 1938, President BRICKWEDDE presiding.

Program: E. A. JOHNSON: *Measurement of small magnetic moments.*—In order to measure the magnetic polarization of weakly magnetized sediments, an electromagnetic method of measurement has been developed which is very sensitive. The magnet to be measured is rotated inside of a fixed coil at ten cycles per second and the voltage induced in the coil is measured by an alternating-current amplifier and synchronous commutator. The limiting sensitivity is computed from the calculated signal voltage and the thermal agitation in the input circuit. The limiting sensitivity can be obtained in practice. Moments of 3×10^{-7} CGS unit can be detected and with specimens 1.5 cm on a side 8×10^{-8} CGS unit/cc can be detected. The method has allowed the study of the weak magnetic polarization in unmetamorphosed sediments and has led to interesting results in regard to the direction of the compass in prehistoric times. The direction of polarization can be determined to within 1° with the apparatus. (*Author's abstract.*)

A. G. MCNISH: *The residual magnetization of rocks.*—To extend records of changes in the earth's magnetic field over a greater length of time than is covered by historic records, measurements have been conducted on the residual magnetization of sedimentary rocks. Unmetamorphosed sediments are believed to have acquired their magnetization through alignment of their magnetic constituents under the directive influence of the earth's magnetic field at the time of their formation. Measurements on the deposits of varved Pleistocene clays left at the recession of the last ice-sheet from New England have revealed distinct differences in direction of their residual magnetization suggestive that for a 200-year period studied the average direction of the earth's field was 30° west of its present direction in the same

region. Variations occurring during this period indicate that secular change was in progress at the time with rates of change comparable with those observed today. Measurements on sediments from the bottom of the ocean also reveal secular change, although the measurements on these sediments may not be directly related to present values of declination. (*Author's abstract.*)

The first paper was discussed by Messrs. F. L MOHLER, H. E. MCCOMB, and W. RAMBERG; the second one by Messrs. R. B. KENNARD, N. H. HECK, F. G. BRICKWEDDE, W. J. HUMPHREYS, A. S. HAWKSWORTH, and J. PAWLING.

1144TH MEETING

The 1144th meeting was held in the Cosmos Club Auditorium, Saturday, January 14, 1939, President BRICKWEDDE presiding.

The Retiring President, N. H. HECK, gave an address entitled *From the center of the earth to the sun.* This address was published in this JOURNAL **29**: 189–218. 1939.

1145TH MEETING

The 1145th meeting was held in the Cosmos Club Auditorium, Saturday, January 28, 1939, President BRICKWEDDE presiding.

Program: E. O. HULBURT: *The brightness of the twilight sky.*—The sunlight illumination of the twilight sky was investigated for the purpose of determining the density and temperature of the atmosphere to as great an altitude as possible. As the sun sets, the earth's shadow above the observer moves upward and the region of the atmosphere illuminated by the direct rays of the sun moves to high levels. A reversed sequence of events occurs before dawn. Measurements were made during clear weather of the brightness of the zenith sky for about an hour after sunset and an hour before sunrise. From the measurements, combined with the known intensity of sunlight and the law of scattering of light by air, the density (or pressure) and the temperature of the atmosphere were determined. Corrections were made for secondary scattering which were obtained from measurements of the brightness of the sunset or sunrise glow of the twilight sky near the west or east horizon.

The temperature came out to be between 205° and 235° K from 12 km to about 60 km. Thus, the temperature of the upper air was cold and was roughly constant with altitude. From the temperature the pressure was determined. No important changes were noted with the season from October, 1937, to April, 1938. For altitudes above about 60 km the method fails, since at greater heights the light of the twilight sky is very weak and the corrections due to secondary scattering are relatively large. These results refer only to the atmosphere during conditions of twilight at Washington, D. C., latitude 40° north. In general, one would expect that the upper air grow warmer during the day and cooler at night. However, the day and night change between 20 and 60 km may not be very great, and might be supposed to increase with increasing altitude. (*Author's abstract.*)

R. E. GIBSON: *Effect of pressure and temperature on the transmission of light by certain solutions.*—The solutions of aromatic amines in nitrobenzene are highly colored even though the pure components are practically colorless. This paper presented the results of a study of the light transmitted at different pressures and temperatures by some of these solutions, especially those of aniline in nitrobenzene which under ordinary conditions have a deep orange color. It was found that rise of pressure at constant temperature

decreased the amount of light transmitted by the solutions much more strongly than could be accounted for by the compressibility of liquids. As the light of shorter wave lengths (green and yellow) was absorbed more strongly at the higher pressures, the visible effect was an apparent change in the color of the solution. It was also found that the increase of temperature at constant pressure had no detectable effect on the transmission of light by these solutions, even when the volume change produced by a given change of temperature, e.g., 85 to 25°, was approximately the same as that produced by a rise of pressure, viz., 1 to 1,000 atm.

The absence of a temperature coefficient together with other thermodynamic properties of the solutions made it highly improbable that the color of these solutions was due to the formation of addition compounds, and, to account for the absorption of light by the solutions and its change with increase of pressure, the hypothesis was advanced that the amount of light of the longer wave lengths absorbed by the solutions was determined by the frequency and violence of collisions between the nitro and amino groups on the unlike molecules. Additional evidence in favor of this hypothesis was presented.

Taking into account the known behavior of the oxygen atoms in the nitro groups as electron-attracting groups and the known tendency of the $-NR_3$ group to act as an electron-repelling group, a mechanism was suggested whereby at the moment of collision an aromatic amine might lower the energy of the excited state of the nitro-group in nitrobenzene. As confirmatory evidence the behavior of solutions of p-nitro-acetanilide in nitrobenzene which are practically colorless was cited.

Studies of the effect of pressure and temperature on the light transmitted by these solutions suggest that in these solutions we have examples of the limiting case of compound formation in solution and of the production of profound changes in the light-absorption of molecules by intermolecular disturbances.

The first paper was discussed by Messrs. J. PAWLING, F. L. MOHLER, L. B. TUCKERMAN, P. A. SMITH, W. G. BROMBACHER, and W. L. HUMPHREYS; the second one by Messrs. P. A. ROLLER, J. A. DUERKSON, W. J. HUMPHREYS, and J. BECK, JR.

MR. J. PAWLING presented an informal communication consisting of a typical photograph of two sunspots.

1146TH MEETING

The 1146th meeting was held in the Cosmos Club Auditorium, Saturday, February 11, 1939, President BRICKWEDDE presiding.

Program: H. F. STIMSON: *The measurement of the specific heat and the latent heat of water from 0° to 100°C.*—Precise determinations were made of the specific heat of water from 0°C to 100°C. These are of value in determinations where water is used as a standard of heat capacity. The latent heat of vaporization was determined at 15 selected temperatures from 100°C down to 0.15°C.

The theory of the method was outlined and the apparatus described. Some of the precautions to attain accuracy were enumerated and the formulation of the results described. The agreement of the formulation with the experimental results for the specific heat showed a precision of better than one part in 10,000 but it was pointed out that the accuracy is not necessarily that high. (*Author's abstract.*)

E. TELLER: *Report on the theoretical conference on low temperature phenomena.*—This year's Theoretical Conference centered around low temperature physics. One of the main questions was connected with the magnetic method for production of extremely low temperatures. To reach low temperatures it is necessary to find some modes of motion that will persist to low temperatures. Such motion is that of the magnetic dipole of electrons and the question discussed at the conference concerned the coupling of magnetic dipoles with other degrees of freedom. Another group of questions was related to the zero-point energy of the lightest atoms. This zero-point energy is responsible for the different behaviors of solid or liquid hydrogen and deuterium. The remarkable properties of the low temperature modification of liquid helium are, however, the most striking illustrations of quantum effect. For this liquid helium the designation "quantum helium" has been used, since it is zero-point energy rather than temperature motion that keeps it from solidifying. Liquid helium also may serve as a model for the droplet theory of the atomic nucleus. (*Author's abstract.*)

The first of these papers was discussed by Messrs. F. D. ROSSINI, F. C. KRACEK, W. F. WHITE, W. J. HUMPHREYS, L. B. TUCKERMAN, and J. PAWLING; the second one by Messrs. A. S. HAWKSWORTH, L. R. MAXWELL, F. D. ROSSINI, and F. G. BRICKWEDDE.

1147TH MEETING

The 1147th meeting was held in the Cosmos Club Auditorium, Saturday, February 25, 1939, Vice-President GIBSON presiding.

Program: J. PAWLING: *The formation of a revised second Bordeaux catalog.*

H. C. HAYES: *Sap flow and pressure in birch trees.*

Sap flow resembles respiration rather than circulation. The tree starts taking in sap under certain stimulating conditions that are not fully understood and continues until boiler pressures of considerable magnitude are established. After maintaining these high pressures for a period of several hours the tree starts expelling sap and continues until the pressure approaches zero and occasionally becomes less than atmospheric pressure. Maximum pressures slightly in excess of 200 centimeters of mercury above and minimum pressures as low as 6 centimeters of mercury below atmospheric pressure have been recorded.

Sap pressure appears to be independent of the size or height of the tree. It tends to rise and fall with the temperature, but no relation between temperature and pressure has been established or even approximated. Moreover, a comparison of many simultaneous temperature and pressure records leads to the belief that factors other than temperature must operate to account for some of the rapid pressure fluctuations where changes as great as 2 or 3 cm of mercury may occur within a minute of time during which there is no measurable change of temperature. Such pressure influencing factors, if they exist, can be traced to the sun for the reason that these small, erratic and relatively rapid pressure fluctuations do not occur during the night.

Pressure changes occur practically simultaneously in all trees in the same locality. This statement apparently holds even for the small rapid pressure fluctuations which are usually present during the hours of sunshine. This fact proves that the stimulus causing the change of sap pressure in a tree comes from without the tree.

The resistance to sap flow through the tree varies between wide limits becoming surprisingly small during the periods when the pressure is high

and active to much greater values when the pressure is low and inactive.

The seat of the sap pressure lies in the new cell growth about the tips of the tiny root hairs. Both pressure and pressure changes appear to depend on the vital activity of these cells because their experimentally determined values can not be accounted for by osmosis and/or capillary action. These cells apparently have the ability to store energy which, under some external stimulus not fully understood, is expended in forcing sap into the trees against pressures approaching 40 pounds per square inch and in maintaining such pressures over periods of several hours. The termination of such pressure periods appears to be definite and practically simultaneous in all trees of the locality as though it were caused by cessation of the pressure-inducing stimulus which then permits the sap to pass outward to the soil through the action of gravity. There is also the possibility that the outward flow of sap is due in part to reversal of activity and not to inactivity of the root cells.

The first of these papers was discussed by Messrs. H. F. STIMSON, A. S. HAWKSWORTH, P. A. SMITH, W. J. HUMPHREYS, R. J. SEEGER, and C. BARAFF; the second one by Messrs. P. S. ROLLER and P. A. SMITH.

1148TH MEETING

The 1148th meeting was held in the Cosmos Club Auditorium, Saturday, March 11, 1939, President BRICKWEDDE presiding.

Program: RICHARD B. ROBERTS, Department of Terrestrial Magnetism of the Carnegie Institution: *The splitting of uranium and thorium nuclei by neutrons.*—Several years ago Fermi and collaborators observed that artificial radioactivity is induced when uranium is bombarded by neutrons. Recently Hahn and Strassman have shown by chemical methods that among the radioactive elements produced are barium, cerium, and lanthanum. This observation was explained by Meitner and Frisch as a fission on the uranium nucleus into two roughly equal parts with approximately 200 million electron-volts of energy released in the process. This theory was soon confirmed by observing the ionization produced by these heavy and highly energetic particles. Neutrons were also found to be emitted in this fission process and these neutrons might conceivably lead to an exothermic chain-reaction. However, it appears very probable that separated isotopes of uranium in large quantities would be necessary to sustain such a chain-reaction. (*Author's abstract.*)

MICHAEL GOLDBERG: *Linkage mechanisms in three dimensions.*—A closed chain of n hinged links in three dimensions (that is, a linkage in which the hinges are not all parallel) has, in general, n-6 degrees of freedom. When n is less than seven, the linkage is generally rigid; a movable chain is said to be "paradoxical." Models of the known paradoxical linkages of less than seven links were exhibited and discussed. These included the plane and spherical linkages, the Bricard 6-bar linkage, which is the basis of the deformable octahedron, the Bennett 4-bar linkage, a new 5-bar linkage and two new 6-bar linkages discovered by the speaker, plane and line symmetric 6-bar linkages, a special 6-bar linkage of 90° twisted links, and several classes of linkages employing plane links. (*Author's abstract.*)

The first paper was discussed by Messrs. E. TELLER, W. G. BROMBACHER, F. C. KRACEK, C. BARAFF, and L. R. MAXWELL.

1149TH MEETING

The 1149th meeting was held jointly with the Washington Academy of Sciences in the Cosmos Club Auditorium, March 16, 1939, with President CHAMBERS of the Academy presiding.

Professor ENRICO FERMI, Department of Physics, Columbia University, spoke on *The mesotron*. The lecture was discussed by members of the Academy and of the Philosophical Society.

1150TH MEETING

The 1150th meeting was held in the Cosmos Club Auditorium, Saturday, March 25, 1939, President BRICKWEDDE presiding.

The Ninth Joseph Henry Lecture entitled *Recent developments of cosmic-ray investigation* was delivered by Dr. THOMAS H. JOHNSTON, Assistant Director of the Bartol Foundation of the Franklin Institute. This lecture, which was discussed by Mr. C. BARAFF, has been published in this JOURNAL **29**: 233–256. 1939.

1151ST MEETING

The 1151st meeting was held in the Cosmos Club Auditorium, Saturday, April 8, 1939, President BRICKWEDDE presiding.

Program: CHARLES K. GREEN, Coast and Geodetic Survey: *Submarine topography in the pilot house.*—Until the advent of echo sounding the average mariner gave but little thought to the configuration of the ocean bottom while cruising in deep water. As long as his course was free from dangers it mattered little whether the vessel at the moment was passing over a submarine knoll or a steep sided canyon. He could not utilize the charted depths for fixing his position without stopping the ship and measuring the depth with a wire—a time-consuming procedure resorted to in exceptional cases only. For ordinary navigation in deep water it was not practicable to use this method.

Today, however, it is possible to obtain a continuous profile of the bottom with the vessel underway. This means that deep-water bottom relief has become important to the man in the Pilot House, since it is available for practical use in guiding his ship. Bottom features in deep water areas are not readily discernible on the conventional chart, on which soundings only are shown. A new method of charting was therefore needed.

The first nautical chart to show detailed bottom relief by depth contours has just been issued by the Director of the Coast and Geodetic Survey. This chart, 5101A, covers the area off the coast of Southern California and the 50-fathom depth contours printed in blue bring into prominence the many submarine "landmarks" useful to mariners in fixing position by echo sounding.

By this method of charting, full use can be made of the survey data, whereas on the conventional type chart of this area, only two percent of the soundings could be used without impairing legibility. (*Author's abstract.*)

O. W. SWAINSON: *Problems of the modern hydrographer.*—To develop radio acoustic ranging to its present state of reliability where the position of soundings taken in hydrographic surveying out of sight of land and for distances up to 200 miles can be obtained, enabling the accurate charting of submarine canyons and mountains, it was necessary to solve many prob-

lems. Some of those described were the development of safe and special bombs to be fired at depths up to 6,000 feet using a single electrical conductor; the determination of the path of the refracted sound wave in sea water; and the overcoming of the difficulty of reflection from submarine canyon walls and mountain sides. A formula was described for obtaining the distance of the bomb from the hydroplane using the approach to parallelism of travel time curves with distances over 30 miles. (*Author's abstract.*)

The first paper was discussed by Messrs. J. PAWLING and M. GOLDBERG; the second one by Messrs. G. T. RUDE, W. BOWIE, P. A. SMITH, and A. S. HAWKSWORTH.

1152D MEETING

The 1152d meeting was held in the Cosmos Club Auditorium, Saturday, April 22, 1939, President BRICKWEDDE presiding.

Program: E. L. KLEIN, Naval Research Laboratory: *Radiation pressure and its measurement.*—The paradoxical history of radiation pressure is recalled. It is pointed out that, whether regarded on the basis of the wave theory or quantum theory, radiant energy possesses momentum. With this momentum is always associated radiation pressure. The smallness of radiation pressure is illustrated by calculating the tremendous power that a searchlight or loud speaker requires in order that the radiation pressure in the beam of light or sound might support a 2-ounce hat. This negligible effect on earth is contrasted with the incredible magnitudes of radiation pressures dealt with in astrophysics.

Devices for measuring radiation pressure of light and of sound are depicted. Apparatus utilizing this effect in standardizing subaqueous acoustics are discussed. It is shown how the radiation pressure developed by a sound generator may be evaluated by two distinct radiometric instruments under identical conditions. Secondary standard microphones are calibrated by the aid of these devices. (*Author's abstract.*)

L. B. TUCKERMAN: *Mathematics as she are taught.*—Very many otherwise competent and well-trained engineers are either afraid of mathematics or scornful of any engineering use of anything but the most elementary mathematics. They can hardly be blamed for this attitude when they find that the so-called mathematics, which they have been taught, repeatedly gives them wrong answers. Some engineering textbooks in wide current use even encourage them in this attitude by sneering at sound mathematical treatment and by treating some mathematical problems in ways which are inadequate, misleading, or even wholly wrong.

Examination of textbooks of algebra, calculus, and function theory in wide current use today shows that these inadequate, misleading, and wrong treatments in engineering textbooks are to be ascribed partly, at least, to equally inadequate, misleading, and wrong treatment of fundamental principles with which many mathematical textbooks, which are supposed to teach mathematics, are filled. It is no wonder that many students give mathematics up as useless and hopeless, convinced that they never can understand it.

These statements are substantiated by many excerpts (shown as lantern slides) from textbooks in wide current use, containing, not a few minor slips, but many different inadequate, misleading, and wrong statements about fundamentals.

Fortunately some textbooks are not so bad as those from which these excerpts are taken and some teachers are careful to correct the faults of the texts. Nevertheless there is urgent need for drastic reform of the textbooks and the teaching of elementary mathematics in our schools. (*Author's abstract.*)

The first paper was discussed by Messrs. H. F. STIMSON, P. A. SMITH, A. S. HAWKSWORTH, and H. L. CURTIS; the second by Messrs. A. WERTHEIMER, M. GOLDBERG, and T. DANTZIG.

1153D MEETING

The 1153d meeting was held in the Cosmos Club Auditorium, Saturday, May 6, 1939, President BRICKWEDDE presiding.

Program: H. L. CURTIS, C. MOON, M. SPARKS, F. WENNER, J. L. THOMAS, I. L. COOTER, F. R. KOTTER: *Absolute measurements of electrical resistance.*— The resistance of a conductor in absolute ohms is the ratio of the potential difference between its terminals, in absolute volts, to the current, in absolute amperes, which is flowing through the conductor. However, the determination of the resistance in absolute ohms has usually been made by methods which do not require the measurement, in absolute units, either of the potential difference or of the current. By the methods used at the National Bureau of Standards a comparison is made of the potential difference between the terminals of a resistor carrying a current and the electromotive force which is induced in an inductor when this same current is changing in a definite manner. Then the absolute value of the resistance is obtained from the value of the inductance, which may be computed from its dimensions, and from a time interval which is determined from the manner in which the current changes. At the National Bureau of Standards two different methods have been carried to completion, in one of which a self inductance was employed and in the other a mutual inductance.

I. Self-Inductance Method. In the self-inductance method an alternating current bridge was used for comparing the self inductance with a capacitance and two resistances. The capacitance was then measured in a direct-current bridge in which the capacitor was charged and discharged a known number of times per second. The capacitance could be eliminated between the equations which connect the constants of these two bridges so that the inductance was determined in international henrys when the resistances of the two bridges were in international ohms. The value of the inductance in absolute henrys was computed from the mechanical dimensions of the inductor and the permeability of the space which surrounded it. The ratio of these two values of the inductance gave the correction factor for converting the value of a resistance in international ohms to its value in absolute ohms.

The self inductor used in the determinations outlined above was a single-layer solenoid. The solenoid was wound on a pyrex glass form, over a meter in length, in which a screw thread was cut and lapped on the outer surface. Two problems were involved, one to have the pitch uniform, the other to have the diameter uniform. The method of lapping gave a pitch which was so uniform that methods of measurement were not available for showing that there were any variations. The maximum variation in diameter was about one micron. In order to have the wire sufficiently uniform in diameter and free from kinks, it was drawn directly onto the cylinder. When a flat oilstone was passed lightly along the length of the finished solenoid, a spot

was polished on each of the wires; the depth of a spot being less than a micron in every case. If there had been a variation in the diameter of the wire as much as 0.1 micron it could readily have been detected by observing these spots.

II. Mutual-Inductance Method. The method of measurements involved: (1) cyclic reversals of the current in the primary winding of the mutual inductor without opening the primary circuit; (2) cyclic reversals of the connections to the secondary winding without opening the secondary circuit; (3) the maintenance of a practically constant current in that part of the primary circuit containing the resistance which was being measured; (4) the maintenance of a practically zero current in the secondary circuit when adjustments were such that the rectified value of the induced electromotive force was equal to the potential drop across the resistor; (5) when adjustments are properly made, $R=4nM$, where R is the measured resistance, n is the frequency of the primary current cycle and M is the mutual inductance. When M is expressed as the product of cm, μ_0 and 10^{-9}, and n is the number of cycles per second, R is in absolute ohms.

The mutual inductor was a modification of the Campbell type. The primary was a solenoid wound on a porcelain form and constructed by a somewhat similar method to that used for the solenoid in the self inductance method. However, the winding was not continuous but had two gaps which were symmetrical with respect to the center. This type of winding gave, outside the primary, a region in which the magnetic field was practically zero. The second winding was placed in this region. The secondary was wound in a groove made by cementing together three plate-glass rings, all having the same inside diameter but the two outer ones having a larger outside diameter than the inner ring.

III. Results. The ratio of the absolute ohm to the international ohm by the two methods is in very satisfactory agreement. The average value by the self inductance method for 104 measurements taken during the past year can be stated as

1 NBS international ohm = 1.000 484 absolute ohms.

The value so far obtained by the mutual inductance method is

1 NBS international ohm = 1.000 485 absolute ohms.

(*Authors' abstract.*)

The above program was presented as four papers. The theory of the self-inductance method was presented by H. L. CURTIS, the experimental procedure and results of that method by C. MOON, the mutual inductance method by F. WENNER, and the mutual inductor by J. L. THOMAS. These papers were discussed by Messrs. P. A. SMITH, L. B. TUCKERMAN, C. SNOW, A. S. HAWKSWORTH, E. BUCKINGHAM, and E. C. CRITTENDEN.

1154TH MEETING

The 1154th meeting was held in the Cosmos Club Auditorium, Saturday, May 20, 1939, President BRICKWEDDE presiding.

Program: A. BRAMLEY, Bureau of Chemistry and Soils: *A thermal method for the separation of gases and isotopes.*—Methods for separating gases by thermal diffusion [Chapman and Dootson, Phil. Mag. **33**, 248 (1917)] have been improved by making the process accumulative [Clusius and Dickel, Naturwiss. **33**, 546 (1938); Brower and Bramley, Phys. Rev. **55**, 590 (1939);

Bramley and Brower, American Chemical Society Abstracts, Baltimore Meeting (1939)]. Our glass apparatus consists of two concentric cylinders, the inner one heated, the outer one cooled. Measurements were taken on a 50–50 mixture of CH_4 and NH_3 at 20 cm pressure. The cylinders were 100 cm long; the inner cylinder had a diameter of 1 cm. As the diameter of the outer cylinder was changed from 1.3 cm to 5.4 cm, the separation went through a broad maximum. As the optimum diameter of 2.5 cm the mixture showed a 27 percent enrichment of NH_3 at the bottom. With this apparatus, diameter of outer tube 2.5 cm and inner 1 cm, measurements were made on the effect of time, temperature, and pressure. At a pressure of 20 cm and average temperature of 150°C. the separation reached 90 percent of its final value in 15 minutes. At this same pressure, the separation increased as the average temperature of the gas increased up to 170°C. With a fixed power input, the separation increased as the pressure decreased from 60 to 20 cm; below that it decreased again. Measurements have been made on separating the chlorine isotopes of HCl. (*Author's abstract.*)

BRIAN O'BRIEN, Institute of Optics of Rochester University: *The problems of solar variability and new methods of attack.*—There are many indications of variability of the sun. The number and distribution of sun spots exhibiting clearly an eleven-year periodicity, changes in form of the solar corona, fluctuations in the earth's magnetic field, and changes in the ionosphere all give evidence of periodic variation of solar origin. The recent and excellent correlation between radio fade-outs and chromosphere flares is further evidence of solar variation reflected in terrestrial phenomena.

Perhaps the most direct method of attack on the problem of solar variation is the systematic measurement of radiation received from the sun. This offers no great problems so far as the determination of radiation received at the earth's surface, but to remove terrestrial effects from such measurements it is necessary to determine, at the same time, the transmission coefficients of the earth's atmosphere. The difficulties of determining these precisely are very considerable, but this problem has been attacked with much success by the Smithsonian Institution over a period of years. As a result the total radiation emitted by the sun, the form of its spectral energy curve, and the spectral transmission coefficients of the terrestrial atmosphere under clear air conditions are known with high accuracy.

The fluctuations observed in total radiation as received from the sun outside the earth's atmosphere are small, but there is reason to believe that these may be of much importance. Any improvements in the accuracy of determination of the atmospheric transmission coefficients (the principal source of uncertainties) are thus very desirable. While measurements are less complete there is good evidence that fluctuations in solar radiation are much greater in the near ultraviolet than are those at longer wave lengths.

In view of the above we have attacked the problem by measurement in the ultraviolet and at high levels in the earth's atmosphere. This is being done in two ways. By the use of sounding balloons, photoelectric keyed radio-telemetering instruments are carried to altitudes of the order of 20 km, above which level the uncertainties remaining in atmospheric transmission are very small. While excellent in principle, this method imposes very severe operating conditions for a precision instrument. The second method, which is applied independently, consists in precise measurement at two spectral regions (one in the ultraviolet and one in the infrared both removed from regions of strong absorption) of the solar radiation simul-

taneously at the earth's surface and at altitudes attainable by an airplane. By this means the uncertainties in transmission of the lower atmosphere due to dust, water droplets and other contaminations are eliminated.

Although both methods are being tested experimentally, the instrumental precision is not yet as great as desired, and development work is being continued. Details of this will be discussed. (*Author's abstract.*)

The first of these papers was discussed by Messrs. R. E. GIBSON, A. K. BREWER, L. R. MAXWELL, and L. B. TUCKERMAN; the second by Messrs. F. L. MOHLER, L. R. MAXWELL, T. A. SMITH, L. B. TUCKERMAN, C. G. ABBOT, and H. L. CURTIS.

RAYMOND J. SEEGER, *Recording Secretary*